Máster Internacional en
GESTIÓN PESQUERA SOSTENIBLE
(7ª edición: 2017-2019)

# TESIS

presentada y públicamente defendida
para la obtención del título de

## MASTER OF SCIENCE

# Vulnerability Assessment applied on case studies from Western and Eastern Mediterranean Small-scale and Industrial Fishing (NAFO area)

MAURO GÓMEZ MURCIANO
Septiembre 2019

| Universitat d'Alacant Universidad de Alicante | GOBIERNO DE ESPAÑA MINISTERIO DE AGRICULTURA, PESCA Y ALIMENTACIÓN | CIHEAM Instituto Agronómico Mediterráneo de Zaragoza |
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**DEL TÍTULO DE MASTER OF SCIENCE EN GESTIÓN PESQUERA SOSTENIBLE**

Alicante

A 9 de septiembre de 2019

# Vulnerability Assessment applied on case studies from Western and Eastern Mediterranean Small-scale and Industrial Fishing (NAFO area).

MAURO GÓMEZ MURCIANO

Trabajo realizado en Faculty of Fisheries / *EGE University* de Turquía, bajo la dirección de Dr. Vahdet Ünal and Dr. Yajie Liu.

Y presentado como requisito parcial para la obtención del Diploma Master of Science en Gestión Pesquera Sostenible otorgado por la Universidad de Alicante a través de Facultad de Ciencias y el Centro Internacional de Altos Estudios Agronómicos Mediterráneos (CIHEAM) a través del Instituto Agronómico Mediterráneo de Zaragoza (IAMZ).

Vº Bº Tutor/a

Autor/a

Fdo: D. Vahdet Ünal y Dª. Yajie Liu

Fdo: D. Mauro Gómez Murciano a 9 de septiembre de 2019

*El mar. La mar.*
*El mar. ¡Sólo la mar!*
*¿Por qué me trajiste, padre,*
*a la ciudad?*
*¿Por qué me desenterraste*
*del mar?*
*En sueños, la marejada*
*me tira del corazón.*
*Se lo quisiera llevar.*
*Padre, ¿por qué me trajiste*
*acá?*

*Rafael Alberti*

ACKNOWLEDGEMENTS

The author wants to personally acknowledge the gratitude to various people, who made the realization of the project possible, thanks to their support and collaboration:

To Yajie Liu for creating the questionnaires that I used in my fieldwork to develop this project. Also for helping me in moments of frustration and sharing her thoughts and ideas with me. Yajie, don't panic!

To Vahdet Ünal for the fresh beers after work. For helping me to get to know, first hand, the fishermen and their outlook on life. In other words, for teaching me another culture. But above all, for having given me this new and wonderful experience and by welcoming me, so affectionately, under his tutelage.

To Aitor Santiago Forcada Almarcha and, especially, to Jose Luis Sánchez-Lizaso for coordinating the master's degree on Sustainable Fisheries Management. This has allowed me to acquire a great deal of new knowledge and establish a lot of new relationships, both professionally and emotionally.

To the Fishermen because without their help and commitment this work would not have been possible.

To my parents, for supporting me at all times. They are the engine that has driven me all this time and they have been able to encourage me and not allow me to flake at any point. These two people are the ones who have taken care of me and made sure that at all times I would never lack anything. Without them I would not be here, I owe them many things, but above all, I owe them for the affection and the enormous support they have given me during these years. Mom, Dad; I love you!

To all of them, thank you very much!

SUMMARY

Together with pollution and overfishing, climate change is the greatest environmental threat to the fishing industry. Climate change is impacting and will continue to impact marine fisheries. These impacts generate a series of mishaps for the fishing activity at the biological, economic and social levels. For these reason, the aim of this study is to assess the various threats to fisheries, focusing on climate change. To perform this task, Vulnerability Assessment was the methodology employed. Vulnerability has three components: 1) Exposure, 2) Sensitivity and 3) Adaptive Capacity. Vulnerability was measured with the data and information collected through the surveys. The surveys were carried out among fishermen from the small scale-fishing fleets of Castelló (Spain) and Aegean Sea (Turkey) and one case of industrial fishing in the NAFO area between 2018 and 2019. Survey results show fishermen's perception of climate change. First, the biological factor analysed corresponds to Exposure in Vulnerability Assessment. On the one hand, “Climate factors” is the most important indicator that is perceived like a threat by fishermen in all regions interviewed. On the other hand, the highest difference between the Mediterranean semi-industrial and Small-Scale Fisheries is the high presence of lessepsian species in the case of Aegean region. Secondly, the economic factor analysed corresponds to Sensitivity in Vulnerability Assessment. In this case, “Fishing revenues” and “Fishing modality” are the indicators that show the highest Sensitivity in the different regions. Next, the social factor analysed corresponds to Adaptive Capacity in Vulnerability Assessment. Each region considers their own specific indicators and it is necessary to implement adaptive measures to improve it. Finally, Vulnerability Assessment analysed the vulnerability to climate change from the three fishing regions. NAFO, Castelló and Aegean regions have the same vulnerability level. In order to mitigate the effects of climate change on fisheries, this study proposes a series of adaptation measures that will help combat climate change in addition to improving measures that are already in place.

*Keywords*: Adaptive Capacity; Climate Change; Fishermen; Vulnerability Assessment.

RESUMEN

Junto con la contaminación y la sobrepesca, el Cambio Climático es la mayor amenaza medioambiental a la que se enfrenta la industria pesquera. El cambio climático está afectando y seguirá afectando a las pesquerías marinas. Estos impactos suponen una serie de inconvenientes para la actividad pesquera a nivel biológico, económico y social. Por esta razón, el objetivo de este estudio fue evaluar las diversas amenazas de la pesca, centrándose en el cambio climático. Para llevar a cabo esta tarea, la metodología empleada fue la Evaluación de Vulnerabilidad. La Vulnerabilidad tiene tres componentes: 1) Exposición, 2) Sensibilidad y 3) Capacidad de Adaptación. La Vulnerabilidad se midió mediante estudios realizados entre los pescadores de las flotas de pesca a pequeña escala de Castellón (España) y del Mar Egeo (Turquía) y un caso de pesca industrial en la zona NAFO; entre 2018 y 2019. Los resultados de la encuesta muestran la percepción de los pescadores frente al cambio climático. En primer lugar, el factor biológico analizado se corresponde con la Exposición en el Análisis de Vulnerabilidad. Por un lado, "Factores climáticos" es el indicador más importante que los pescadores perciben como una amenaza, en todas las regiones entrevistadas. Por otro lado, la mayor diferencia entre las flotas artesanales y semi-industriales mediterráneas entrevistadas es la alta presencia de especies lesspsianas, en el caso de la región del mar Egeo. En segundo lugar, el factor económico analizado se corresponde con la Sensibilidad en el Análisis de Vulnerabilidad. En este caso, los "Ingresos por pesca" y la "Modalidad de pesca" son los indicadores que muestran, en todas las regiones, valores positivos más altos. A continuación, el factor social analizado se corresponde con la Capacidad Adaptativa en Análisis de Vulnerabilidad. Cada región considera sus propios indicadores y es necesario implementar medidas de adaptación para mejorarlos. Finalmente, el Análisis de Vulnerabilidad analizó la vulnerabilidad de las tres regiones pesqueras frente al cambio climático. Las regiones NAFO, Castellón y Egeo tienen el mismo nivel de vulnerabilidad. Con el fin de mitigar los efectos del cambio climático en la pesca, este estudio propone una serie de medidas de adaptación que ayudarán a combatir el cambio climático además de mejorar las medidas ya existentes.

*Palabras clave*: Capacidad Adaptativa; Cambio Climático; Pescadores; Evaluación de Vulnerabilidad.

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## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| **%** | Percentage |
| **°C** | Celsius degree |
| **€** | Euro |
| **AC** | Adaptive Capacity |
| **CC** | Climate Change |
| **CFP** | Common Fisheries Policy |
| **$CH_4$** | Methane |
| **$CO_2$** | Carbon dioxide |
| **D** | Decreto (Decree) |
| **DEA** | Diario Electrónico de Abordo (On-board Electronic Journal) |
| **E** | Exposure |
| **EU** | European Union |
| **EMFF** | European Maritime and Fisheries Fund |
| ***et al*.** | *Et alii* (and others) |
| **FAO** | Food and Agriculture Organization of the United Nations |
| **Fig.** | Figure |
| **F/V** | Fishing Vessel |
| **GVA** | Generalitat Valenciana |
| **ICZM** | Integrated Coastal Zone Management |
| **IEO** | Instituto Español de Oceanografía (Spanish Oceanographic Institute) |
| **IMP** | Integrated Maritime Policy |
| **INE** | Instituto Nacional de Estadística (Statistics National Institute) |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **MPA** | Marine Protected Area |
| **MT** | Metric Tons |
| **NAFO** | Northwest Atlantic Fisheries Organization |
| **NASA** | National Aeronautics and Space Administration |
| **NGO** | Non-Governmental Organization |

**NK/NA** No Know / No Answer

**$NO_2$** Nitrogen dioxide

**O** Orden (Order)

**PCA** Principal Component Analysis

**PHC** Primary Health Care

**R** Reglamento (Regulation)

**RFMO** Regional Fishery Management Organization

**S** Sensitivity

**SSF** Small Scale Fisheries

**UNFCCC** United Nations Framework Convention on Climate Change

**U.S.A.** United States of America

**VA** Vulnerability Assessment

**WMO** World Meteorological Organization

# 1 INTRODUCTION

There is a great variety of threats that make fishing a vulnerable activity, for example: overfishing, habitat destruction, human interactions with marine ecosystems, marine pollution, invasive species and climate change (CC) (Rilov *et al.*, 2017). Practically all of them are caused by human activities, so there are actions that can be remedied in the future.

The first problem that threatens fishing, from within the sector itself, is overfishing (the quantity of exploited stocks was reduced by reducing catches below the level that can be produced by the Maximum Sustainable Yield). Not only does it have negative ecological consequences, but it also reduces fisheries production in the long term, which subsequently leads to negative social and economic consequences (FAO, 2018). On a global scale, if some fishing continues in an unsustainable manner, the percentage of fisheries experiencing overfishing would increase from the currently estimated level of 65 % to a level of 72 % (McDermott *et al.*, 2019).

Secondly, human's influence on the climate system is clear. Yet determining whether such influence constitutes "dangerous anthropogenic interference" in the words of Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC) involves both risk assessment and value judgements. Most human-induced disturbances in marine ecosystems increased when disturbances caused by warming oceans began to become widespread (IPCC_A, 2014).

From a fisheries perspective, two types of ocean pollution are of particular concern. The first is abandoned fishing gear, lost or discarded from capture fisheries, which have negative effects on fisheries and the marine ecosystem (FAO, 2018). The second is microplastics. Plastic pollution has been a menace to our society for decades (Solomon *et al.*, 2018). In coastal areas, the marine pollution of plastic is increasing at an alarming rate due to indiscriminate disposal by the consumers (beach visitors, tourists, shipping/maritime companies, fishery operators) with its continued growing production (Kiessling *et al.*, 2017).

Finally, the global CC affecting the Earth's atmospheric and oceanic system interacts in many ways with global biogeographic changes arising from marine species translocations. Rising temperatures are aiding the establishment of foreign species into the Mediterranean. These species are mostly introduced via the Suez Canal and their successful establishment is believed to have been assisted in recent years by CC (UNEP, 2009; Ünal *et al*., 2015). The most dominant ones were the two Red Sea rabbitfish, *Siganus rivulatus* and *S. luridus* that were first documented on the Levant reefs in 1924 and 1955, respectively (Rilov *et al.*, 2017).

Of all the existing threats, CC is one of the most debated and studied topics in recent years. Doing a quick search (with SCOPUS citation database), close to 1.200.000 publications on this subject appear over the last 20 years. Likewise if we add the term "marine science", 277.000 publications continue to appear on this subject. This research is about the main threats to fisheries in relation to CC. Searching this topic appears 96.700 publications. For this reason, let's start by explaining what CC is and what problems it brings about.

## 1.1 Climate Change

### 1.1.1 Definitions:

According to the World Meteorological Organization (WMO), this term encompasses all forms of climatic inconsistency, regardless of their statistical nature or physical causes. CC may result from such factors as changes in solar emission, long-term changes in the Earth's orbital elements (eccentricity, obliquity of the ecliptic, precession of the equinoxes), natural internal processes of the climate system, or anthropogenic forcing (FAO, 2008).

But the WMO definition is not the only one, depending on the approach and use made of it. For example, the UNFCCC defines CC as "a change of climate that is attributed, directly or indirectly, to human activity, alters the composition of the global atmosphere and is in addition to the natural climate variability observed over comparable periods" (FAO, 2012).

In Intergovernmental Panel on Climate Change (IPCC) usage, CC refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity (UNFCCC, 2011).

CC involves complex interactions and changing likelihoods of diverse impacts (IPCC_A, 2014). CC is increasingly accepted as one of the major issues that the human societies have to face in the 21$^{st}$ century. It will have multi directional effects on humanity in terms of several socio-economic factors and other factors like agriculture, health (disease prevalence), rise of sea level, scarcity of labour (Thathsarania and Gunaratneb, 2018), fisheries etc. Several damages will take place unless proper adaptation strategies are implemented in proper time.

Global CC is impacting and will continue to impact marine and estuarine fish and fisheries (Roessig *et al*., 2004). At the global level, the Earth's average surface temperature has increased by more than 0.8 °C since the middle of the nineteenth century, and is now warming at a rate of more than 0.1 °C every decade (Hansen *et al*., 2010). The largest contribution to this warming is believed to be from the increase in atmospheric concentration of greenhouse gases, such as $CO_2$, methane $CH_4$ and nitrogen dioxide $NO_2$ (Bahri *et al*., 2018).

The ocean acts as a buffer by balancing the temperature between the water and the atmosphere. In addition to its thermal capacity, the ocean has also sequestered about 25 % of the $CO_2$ released as a result of anthropogenic activities (Le Quéré *et al*., 2018), playing a crucial role in the regulation of the Earth's climate.

These variations in temperature, and therefore in the physical parameters of the water, modify and destabilise the water column (Fig. 1). This can affect fish habitat, productivity, and distribution, as well as impact fishing operations and the physical infrastructure of coastal communities directly (Cinner *et al.*, 2013).

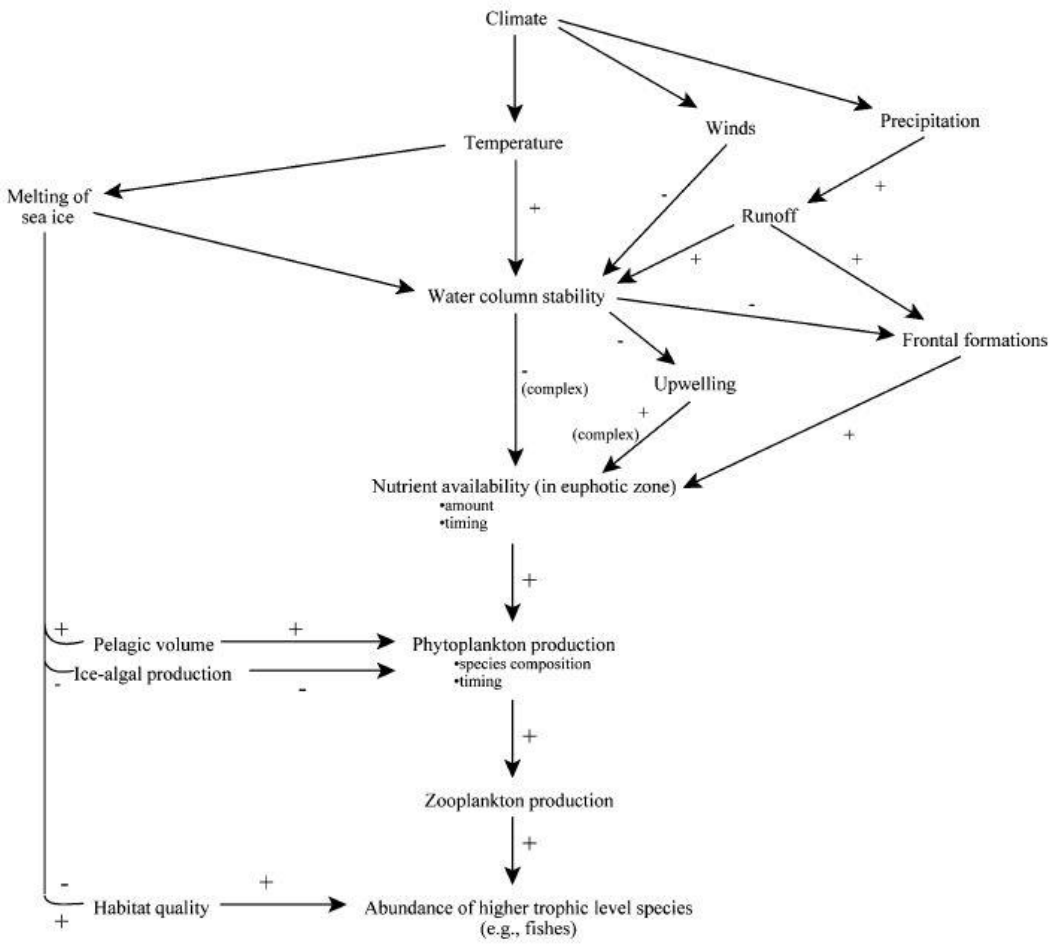


*Figure 1.* The variable effects of climate on oceanographic processes and production affecting marine fishes (Source: Roessig *et al*., 2004).

### 1.1.2 Socio-economic impacts:

The biodiversity changes are likely to have profound direct socio-economic effects on public health (UNEP, 2009). The world's oceans are changing in response to changing climate, these changes have significant consequences, there is much at risk, and action is needed now to increase the resilience of ocean ecosystems and the people that depend on them (Link *et al.*, 2018).

CC is challenging the effectiveness of contemporary fisheries and aquaculture management in many parts of the world and gives rise to significant additional ecological and socio-economic uncertainties (Poulain *et al.*, 2018). Many economies and people are dependent on fisheries (FAO, 2015). Global marine fisheries are underperforming economically because of overfishing, pollution and habitat degradation. Added to these threats is the looming challenge of CC (Sumaila *et al.*, 2011).

Total global marine catches were 79.3 million tonnes in 2016 (FAO, 2018). Gross revenues from marine capture fisheries worldwide are estimated at between 80 billion and 85 billion dollars annually. As a primary industry, fisheries support the well-being of nations through direct employment in fishing, processing and ancillary services amounting to between 220 billion and 235 billion dollars annually (Dyck and Sumaila, 2010).

It is estimated that on the planet Earth there are 40.3 million people who live directly from fishing activities (FAO, 2018). This means that the number of people directly or indirectly supported by marine fisheries is about 520 million, or nearly 8% of the world's population (Sumaila *et al.*, 2011).

The main economic activities of coastal areas are fisheries, aquaculture, agriculture and tourism. Although fisheries have been declining over the last two decades, some fishermen have been converting to agriculture (Snoussi *et al.*, 2008). Only tourism and aquaculture have been expanding rapidly over recent decades.

Understanding what makes coastal societies vulnerable to the aspects of CC is a critical task for scientists, governments and society at large. A vulnerability scan will be will be carried out to perform this task. So, it is possible to understand the effects that will be caused on organisms and populations, how these changes will affect communities and ecosystems, and therefore, how they will affect the economy of those who take advantage of their resources, and if there is the possibility of posing a solution to the problem (Fig. 2). Our ability to impose new management relies on the assessment of vulnerability and AC, and the lack of social-ecological data often stifles decision making (Tilley *et al.*, 2018).

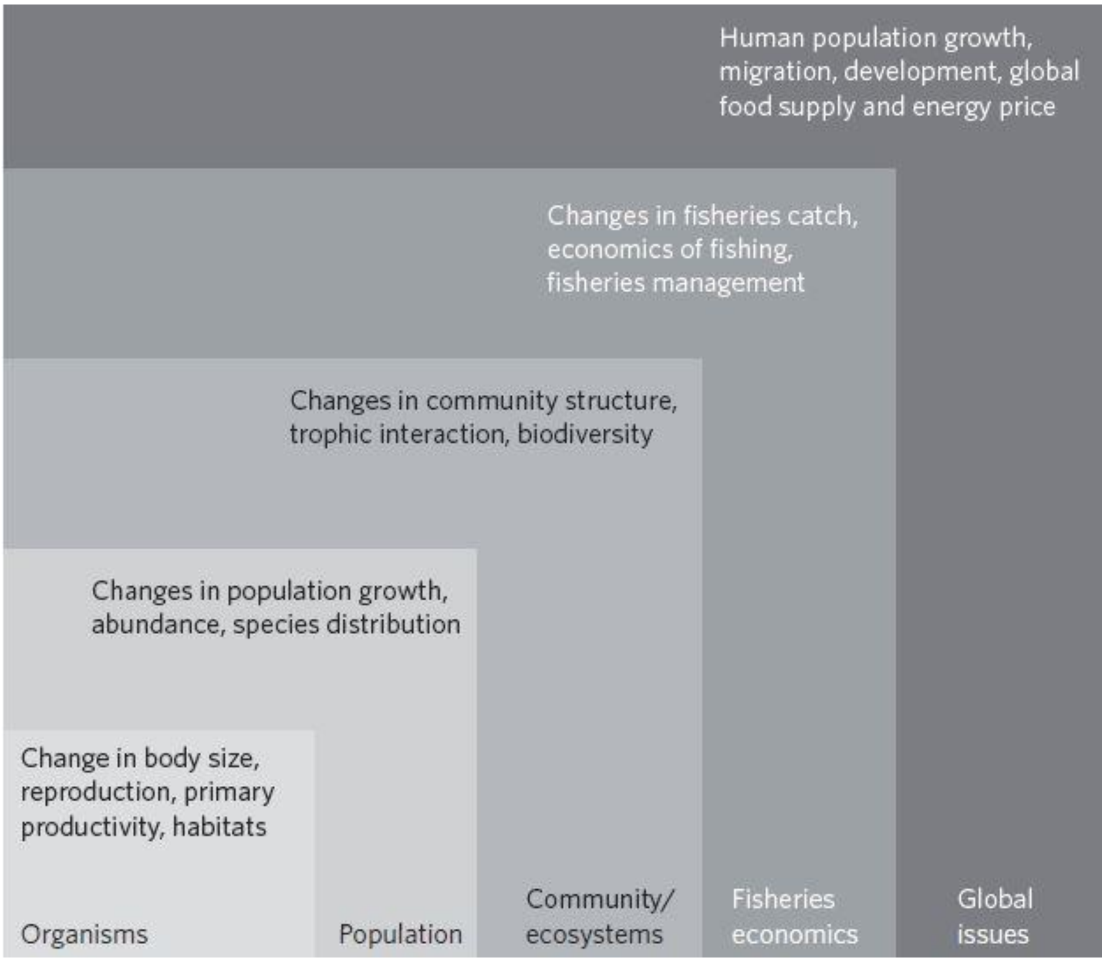


*Figure 2*. Schematic diagram indicating the biophysical and socio-economic impacts of CC on fisheries at different levels of organizations, from individual organisms to the society. (Source: Sumaila *et al.*, 2011).

### 1.2 Vulnerability Assessment

Vulnerability is the propensity or predisposition to be adversely affected (IPCC_A, 2014). There are several different components to examining vulnerability (Fig. 3) of the Mediterranean fishing population in the face of CC (Cinner *et al.*, 2012). These components usually measure: 1) Exposure, 2) Sensitivity and 3) Adaptive Capacity (Adger, 2000 and 2006; Allison *et al.*, 2009). There are no independent measures for them, so their interpretation depends on the scale of the analysis, the particular sector considered and the availability of data (Allison *et al.*, 2009).

Vulnerability, in the context of social and environmental change, is defined as the state of susceptibility to harm from perturbations (Adger, 2006), especially from climatic shocks (Ahsan and Warner, 2014). Knowledge about how vulnerable a system is, and the specific conditions that make it vulnerable, can help to provide a foundation for developing key actions that minimize the impacts of environmental change on people (Cinner *et al.*, 2013).

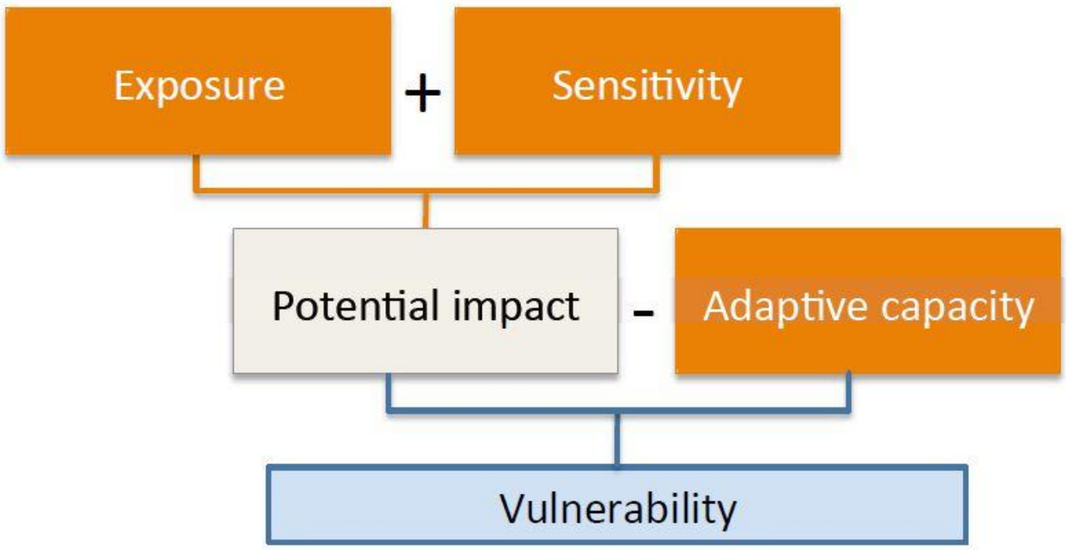


*Figure 3. Conceptual model of vulnerability components (Source: FAO, 2015).*

#### 1.2.1 Exposure:

The degree to which a system is stressed by climate, such as the magnitude, frequency, and duration of a climatic event such as temperature anomalies or extreme weather events (Adger, 2006). Exposure is known as the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC_A, 2014).

Many climate variables influence fisheries through a range of direct and indirect pathways. For fishing communities, Exposure captures how much of the resource they depend on will be affected by environmental change (Cinner *et al.*, 2013). These effects of CC include changes in the abundance and distribution of exploited species (Allison *et al*., 2009) and increases in the frequency and severity of extreme events, such as storms, which affect fishing operations (Adger *et al*., 2005).

### 1.2.2 Sensitivity:

Sensitivity is defined as the intrinsic degree to which biophysical, social and economic conditions may be influenced by extrinsic stresses or hazards (IPCC_A, 2014). In this context, it is represented by dependence on fishing, which is important for the local economy. The Sensitivity of the possible impacts of CC on the fisheries sector as a whole is represented (Allison *et al.*, 2009). Sensitivity, in the context of environmental change, is the susceptibility of a defined component of the system to harm, resulting from Exposure to stresses (Adger, 2006). The Sensitivity of social systems depends on economic, political, cultural and institutional factors that allow buffering or attenuation of change (Cinner *et al.*, 2013).

### 1.2.3 Adaptive Capacity:

The concept of Adaptive Capacity has been used differently in varying contexts (Abdul-Razak and Kruse, 2017). One of the most recently used definition in relation to CC is “The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences" (IPCC_A, 2014). Another definition could be that Adaptive Capacity represents the ability of a region or community to cope with and thrive in the face of change (Thathsarania and Gunaratneb, 2018).

Adaptive Capacity is a latent characteristic that reflects peoples’ ability to anticipate and respond to changes, and to minimize, cope with, and recover from the consequences of change (Adger and Vincent, 2005). In this section, the concept of resilience comes into play, which is the capacity of a system to absorb disturbances and reorganise itself during change in order to preserve essentially the same function, structure, identity and feedback (Holling, 1973).

## 1.3 Global examples of Adaptive Capacity

Literature was reviewed to identify examples of current and recommended adaptations in the fishery sector around the world (Table 1). The literature search targeted a diversity of geographic and biophysical contexts, with an emphasis on most vulnerable areas to CC. The search was carried out to demonstrate the variety of individual and societal adaptation actions employed at different scales around the world (Poulain *et al*., 2018; Fig. 4).

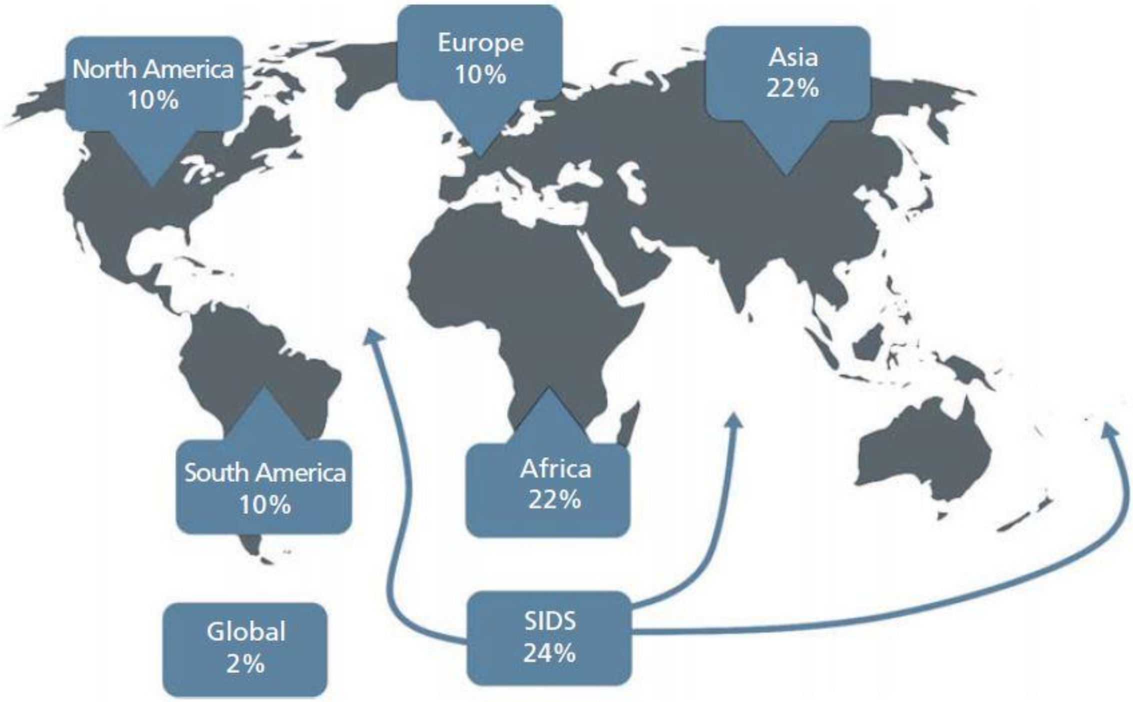


*Figure 4.* Percentage of reviewed adaptation actions by region (Source: Poulain *et al*., 2018).

*Table 1.* International Adaptive Capacity measures implemented.

| COUNTRY | ADAPTIVE CAPACITY MEASURES | REFERENCES |
|---|---|---|
| Asia-Pacific | **MPA monitoring training.** Participants who already had some familiarity with marine environments, MPAs and scuba were trained on marine species identification, monitoring techniques and protocols. The training increased technical capacity for participants, and this training and the training handbook creates the potential for participants to create and implement programme in their own setting and further train others. This could result in further education for and employment in MPAs. | Shelton, 2014 |
| Egypt | **Climate risk assessment**. Risk assessments introduced for integrated coastal zone management initiate controls on coastal development that may negatively affects fisheries or habitats. All future and ongoing coastal development will be | Shelton, 2014 |

| | | |
|---|---|---|
| | evaluated to identify short-term measures that can be linked to long-term adaptation. | |
| Kenya | **Strengthen local community-driven institutions**. Institutions responsible for fisheries management (e.g. beach management units and collaborative fisheries management areas) are strengthened via increased understanding of resources and impacts. Co-management has led to fishery management implementation (where before there had been none or weak enforcement), including reduction in destructive fishing practices, increased trust in management authorities, self-policing of the fishery. Formal co-management has increased national funding for fisheries management at the local level. | Shelton, 2014 |
| Madagascar | **Fishing training.** Train non-fishers on sustainable and safe fishery techniques in anticipation of these changes. Develop fishing techniques adapted to specific contexts (considering how they will change in the future). | Cochrane *et al.*, 2019 |
| Mexico | **Wetland conservation management strategy**. A conservation management strategy will be developed, including updating land zoning regulations and enhancing local area governance. This will build local capacity as well as continue benefits from ecosystem services provided by the wetland (e.g. erosion buffering, water filtration, potential carbon sequestration). | Shelton, 2014 |
| Mexico | **Reducing social vulnerability.** Diversification of the species harvested might be a beneficial strategy. Access and availability to science. | Ekstrom *et al.*, 2015 |
| Morocco | **Integrated Coastal Zone Management (ICZM) plan.** The plan includes building regulation, urban growth planning, development of institutional capacity, and increasing public awareness. This plan should actively involve the local communities and the stake-holders. As such, engagement with CC and implementation of policy response will be more effective. The ICZM plan should also deal with impacts from both climatic and non-climatic change, ensuring that coastal development will not increase the vulnerability of the region. | Snoussi *et al.*, 2008 |
| Mozambique | **Training in agricultural and fishing practices**. Training in practices that are viable in high climate variability scenarios will be provided, including extension service packages tailored to village needs. This will lead to more resilient food production practices, which increase community resilience, especially when combined with new linkages to markets for additional income and diversification opportunities. | Shelton, 2014 |

| | | |
|---|---|---|
| Peru | **Innovative insurance scheme**. Farmers in the coastal region are able to purchase an insurance that uses index-based instruments based on the occurrence of previously established climate data parameters proven to predict damaging events rather than measurement of actual damage (e.g. rise in sea surface temperatures near Peru, which are correlated with El Niño onset). Although not directly related to fisheries or aquaculture, fishing and aquaculture sectors share many similarities with agriculture in terms of profit vulnerability to climate variability. | Shelton, 2014 |
| Seychelles | **Local management**. A local-level coordinating body will be established to oversee VAs, implementation and monitoring of adaptation activities. Local capacity will be built via this coordinating body and associated training for participation in this group. | Shelton, 2014 |
| U.S.A. | **Advance monitoring efforts of climate-driven impacts on species, habitat, and fishing communities**. Documenting environmental and climatic change is key to natural resources management. | Gregg *et al.*, 2016 |

### 1.4 Background and Justification of the Thesis

CC is challenging the effectiveness of contemporary fishery management and gives rise to significant additional uncertainties and threats to fishers and to the fishing industry (Poulain *et al*., 2018). An increasing number of studies have been published on the effects of CC on aquatic populations and fisheries resources (Cheung *et al.*, 2013). In recent years, a number of initiatives have implemented different approaches to better characterize and understand the broad threats and underlying issues facing fisheries (FAO, 2015).

Fishing represents a strong socio-economic relevance for many communities, specially, locations that are allowed to fish close to the sea. For this reason, it is important to identify which threats affect or may affect fishing activity in the future. A VA will be used to perform this task. Vulnerability is the state of susceptibility to harm from Exposure to stresses associated with environmental and social change and from the absence of capacity to adapt (Adger, 2006).

Understanding the potential impacts of CC and society's capacity to adapt to these changes requires analysing the combination of conditions (economic, environmental and social) that contribute to vulnerability, and characterizing locations and segments of society that are most vulnerable (Cinner *et al.*, 2012). In addition, the following should have uncertainty incorporated into decision-making and management process; enhancing natural barriers, protecting fish habitats through adaptive spatial management; and incorporating CC into natural resource planning across sectors (FAO, 2015).

Reviewing the published bibliography, incomprehensibly, only a few studies have been carried out measuring the vulnerability of fisheries to effects of CC. It is therefore necessary to carry out a study to assess the threats facing fisheries. To this end, it is important to determine the factors to which fishing is exposed, identify how sensitive they are to threats and how well they adapt to the disturbances produced by CC.

In order to justify this final master's thesis, emphasis has been placed on the small amount of work dealing with VA applied on fisheries. There are even authors that reflect the inexistence of previous works with these characteristics. For example, no comprehensive evaluation of the vulnerability of fisheries to the effects of CC has been carried out until now (Hidalgo *et al*., 2018). Despite the fact that FAO published a few years earlier a guide on how to develop this methodology. In which it collected some of the papers that used it. The total number of published studies, related with VA applied to fisheries and aquaculture, from 1995 to 2012 is 24 (FAO, 2015). The existence of authors who reflect the inexistence of works with this methodology reflects the lack of them.

However, almost all the published studies use a top-down approach, in other words, they analyse vulnerability based on a big picture starting from a national scale and narrow down different components. The temporal and spatial scales of top-down modelling-based methodologies tend to be longer and larger than bottom-up/qualitative methodologies – reviewed below – which tend to focus on local spatio-temporal scales and contexts (FAO, 2015).

On the contrary, my study focuses on bottom-up approach, surveying various fishers who operate fisheries for their livelihood. Participatory stakeholder-based methodologies typically exemplify bottom-up/ qualitative methodologies. In direct connection with the livelihood perspective on vulnerability, these methodologies often provide a means to study one or more components of livelihoods in relation to vulnerability, and constitute an ideal entry point for the involvement of target groups and beneficiaries themselves in assessments (FAO, 2015).

## 1.5 Project Objectives

CC is caused by a great diversity of variables and has different effects on the environment. In fact, there is a lot of published work on this topic. Because of this, this work does not pretend to focus on what are the causes that have provoked a global CC, but instead:

- Identify vulnerability factors (biological, economic and social) that threaten fisheries.
  - Quantify the degree of Exposure to these risk factors about: two small-scale fishery communities (Castelló and Izmir); and a case of industrial fishing in the NAFO area.
  - Quantify the degree of Sensitivity of these three types of fisheries to the risk factors.
  - Assess the Adaptive Capacity of both fishing communities in order to address the identified risk factors.
- Compare identified vulnerabilities between different fleets:
  - Compare the opinion of Spanish fishermen of the Galician industrial fleet and the inshore fleet of Castelló on the threats to the fishing sector.
  - Compare the opinion of threats to the fishing sector among the fishermen of the different fleets in Castelló.
  - Compare the opinion of threats to the fishing sector among fishermen from the artisanal fleets of Castelló and Turkish Aegean sea fishery cooperatives.
  - Compare the opinion of threats in the fisheries sector among the fishermen of the various fishery cooperatives in the Turkish Aegean Sea.
- Create an index of threats and how to mitigate them, using published literature and collected data.
- Propose a series of new measures to ensure adequate Adaptive Capacity against the risk factors that threaten fisheries.

Given the urgency of CC, the importance of marine resources and the lack of information on risk assessment, it is therefore clear that it is essential to review the factors that threaten fisheries and determine how vulnerable fisheries are to them.

# 2 MATERIAL AND METHDOS

## 2.1 Study areas:

### 2.1.1 Northwest Atlantic Fisheries Organization (NAFO):

Northwest Atlantic Fisheries Organization (NAFO) is the Regional Fisheries Management Organization responsible for the management of fisheries resources within the NAFO Convention Area (Fig. 5) outside coastal states Economic Exclusive Zones in the Northwest Atlantic (Koen-Alonso *et al*., 2018).

The management measures of this RFMO are in the Conservation and Enforcement Measures, this publication incorporates all NAFO Conservation and Enforcement Measures presently in force as adopted by the Commission in accordance with provisions of Articles VI and XIV of the Convention on Cooperation in the Northwest Atlantic Fisheries (NAFO, 2018).

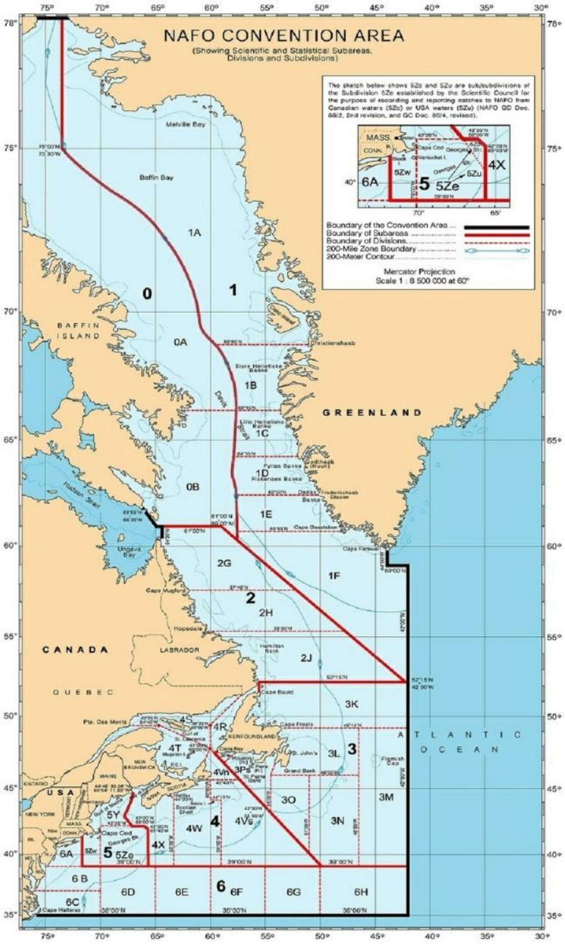


*Figure* 5. NAFO Convention Area and indication of NAFO Sub-Areas, Divisions and Sub-divisions (Source: Government of Canada).

This area has a great presence of species with commercial interest (e.g. snow crab, northern shrimp), where important fisheries are managed by either Fisheries and Oceans Canada or NAFO (Table 2).

The first part of the study was developed in Northwest Atlantic Fisheries Organization. During a period of three months in the summer season of 2018 on board of the trawler F/V Playa de Tambo of the Galician (Spain) fleet. The vessel was fishing on 3MLNO areas. Where the Spanish fleet mainly fishes. These areas correspond with *Flemish Pass*. The species objectives were: American plaice (*Hippoglossoides platessoides*), Redfish (*Sebastes* spp), Greenland halibut (*Reinhardtius hippoglossoides*), Yellowtail flounder (*Limanda ferruginea*) and Thorny skate (*Amblyraja radiata*). This vessel was selected because it is within the scientific observer plan of the IEO of Vigo. This fact facilitated the cooperation of the fishermen.

NAFO area was employed to test the questionnaires. This area and this fishing vessel were selected because the author was on board as a Control Observer. In any case it can be considered a representative sample of the area.

*Table* 2. Northwest Atlantic stocks under NAFO management. SA: Sub-Area (Koen-Alonso *et al.*, 2018).

| Species | Management stocks |
|---|---|
| Atlantic cod | 3M, 3NO |
| American plaice | 3M, 3LNO |
| Redfish | 3M, 3LNO, 3O |
| Greenland halibut | SA2+3KLMNO |
| Yellowtail flounder | 3LNO |
| Witch flounder | 2J3KL, 3NO |
| White hake | 3NOPs |
| Thorny skate | 3LNOPs |
| Capelin | 3NO |
| Northern shrimp | 3M, 3LNO |
| Squid | SA3+4 |

### 2.1.2 Castelló:

*Figure* 6. Location of the city of Castelló de la Plana. Source: Miguel Guillen.

In this part of the study, the VA of Mediterranean fisheries took place in Castelló de la Plana. This city is the capital of the province of Castellon and the region of La Plana Alta, in the Valencian Community (Fig. 6). Located to the east of the Iberian Peninsula, surrounded by different mountain ranges inland and the Mediterranean Sea to the east, before which 10 km of its coastline extends (Ayuntamiento de Castelló). This region was selected on the basis of geographical location. Because it is a close and straightforward area to study.

Fishing employs around 3500 people directly in the Valencian Community and their product at first sale of 31000 MT is estimated at 103760000 € per year. Likewise, the fishing fleet of the Valencian Community is currently made up of 697 vessels. Of which 269 are trawlers, 368 are artisanal fishing, 38 are purse seines, 10 are demersal longlines and 12 are pelagic longlines (GVA, 2019).

Castelló has a population of 170888 habitants (INE) in 2018. Of which a very small part is dedicated to fishing activity. There are only 248 seamen left in a very small fleet (Table 3). The majority of these fishermen are people with limited training and specialized in the maritime-fishing sector. So it would be very difficult for them to find a new job if the current one disappeared. It must also be added that this is an ageing fleet, with an average age of over 45 years.

*Table 3.* Castelló harbour fishing fleet in 2018.

| **FISHING VESSELS** | ***VESSELS NUMBER*** |
|---|---|
| TRAWLING | 13 |
| PURSE-SEINE | 14 |
| SSF | 34 |
| PELAGIC LONGLINE | 2 |

The fishing season runs from February to November, for fishermen engaged in purse seine activity, closed for two months in December and January (O. AAA/399/2016, de 18 de marzo).

The trawl fleet is also temporarily closed in August and September. In this way, they develop their activity from October to July.

Referring to the artisanal fleet, they work throughout the year alternating their gear (gillnet, demersal longline, hook, etc...). In other words, they are not allowed to combine the daily activity of artisanal fishing with other activities of minor gear (D. 48/2018, de 20 de abril). Except for four months (April to May) when the target species is the octopus (R. 5 de julio de 2017). Where the fleet operates almost entirely on this species due to the good yields it generates. The authorized fishing period is five days per week for each vessel. In any case, the weekly rest period is 48 continuous hours (O. APA/254/2008, de 31 de enero).

### 2.1.3 Aegean Sea:

Turkey has 28 coastal cities and four different seas. Marine capture based fishery cooperatives are located along the Marmara, Aegean, Mediterranean and Black seas. Of these areas 21 % of marine fishery cooperatives in Turkey are located in the Aegean region (Ünal *et al.*, 2016).

The Turkish zone in the Aegean Sea, for statistical purposes, extends from the southern end of the Dardanelles in the north, to the coastal city of Muğla-Marmaris in the south. The Turkish sector of the Aegean is very small and narrow, and its width varies from approximately 50 km in the north, to around 10- 15 km for the remainder. The Aegean Sea is known for its turquoise and clear waters due to its extremely low nutrient levels and, consequently, its low marine fishery catches (Ulman *et al*., 2013).

Seven different fishery cooperatives were analysed (Fig. 7) in this region. The cooperatives were selected on the basis of geographical location, the specific characteristics exhibited within the Aegean SSF and their number of fishermen members (Table 4). Three from the southern Aegean coast (Akyaka, Akçapınar and Akbük), three districts were chosen from the central Aegean coast (Mordoğan, Urla and Bostanli, Izmir) and one from the northern Aegean region (Altınoluk).


*Figure* 7. Fishery cooperatives data collected in the Aegean Sea: 1) Altınoluk, 2) Mordoğan, 3) Urla, 4) Bostanli, 5) Akbük, 6) Akyaka and 7) Akçapinar (Source: adapted from minimalaegean).

Another reason for choosing these fishery cooperatives was the trust and prior cooperation of their leaders. All members of these cooperatives are artisanal fishers. The first idea was to interview all kind of fleets in Turkey (trawlers, purse seiners, artisanal, etc.) like in the case of Spain. But this task could not be carried out due to the poor cooperation of the fishermen of these fleets.

*Table 4.* Number of fishermen in fishing cooperatives of the Turkish Aegean Sea.

| *Location* | Altınoluk | Mordoğan | Urla | Bostanli | Akbük | Akyaka | Akçapinar |
|---|---|---|---|---|---|---|---|
| *Fishermen number* | 117 | 65 | 33 | 157 | 11 | 25 | 18 |

## 2.2 Data collection

The surveys were conducted in the same way. But in the case of Turkey, the language employed was Turkish. All interviews were conducted by trained interviewers (final year students of the Faculty of Fisheries of the EGE University). By means of a structured questionnaire and speaking directly with the fishermen. These questionnaires (Annex) are intended to help identify the factors that threaten fishing activity and the degree to which fishermen are aware of these threats. In addition to providing a large amount of both qualitative and quantitative information.

First of all 17 surveys were conducted among members of an industrial fishing vessel. Playa de Tambo F/V, a freezer trawler with its home port in the Galician city of Marín, Pontevedra. These surveys took place during the months of June and September 2018, in the NAFO area. On the one hand, the main objective of these interviews was to refine the questionnaire and identifying the variables. On the other hand, interviews were conducted with the aim of identify differences between the perception of threats by the fishermen of the industrial fleet and the Spanish SSF and semi-industrial fleet.

On the other side, a total of 46 interviews were conducted with the sailors from Castelló. Divided between the different fishing methods: 15 for the trawling fleet, 15 for the artisanal fleet, 15 for the purse-seine fleet and 1 interview of a pelagic longline vessel. The interviews took place during the months of October and November 2018.

Lastly, the Turkey data collection was carried out in different regions (south, central and north Aegean) and fishermen cooperatives. A total of 85 questionnaires were carried out in Turkey Aegean Sea between the months of March and June, both included, of 2019. 17 surveys were conducted in Akyaka, 5 surveys were made in Akbük and 5 surveys were realised in Akçapinar (south Aegean region). 13 surveys took place in Urla, 13 surveys were made in Bostanli, Izmir and another 17 surveys became in Mordoğan (central Aegean Region). 15 surveys were conducted in Altınoluk (northern Aegean Region).

The size of the fleets and the members of them are different. NAFO is the region with less fishermen sampled (only 17). In case of Castelló, there are four different fleets that are working on their coastal waters. The fishermen from the different fleets welcomed the interviews in a positive way and their cooperation was unbeatable except for one small detail. Once the skipper was interviewed, the rest of the sailors did not want to participate in the survey. For this reason, the percentage of answers in this region is low. Finally, in Aegean Sea region, fishermen cooperatives are small, except Altınoluk (north region) and Bostanli (central region). The problem in this region was that in most of the sampled cooperatives there was always a very small number of fishermen. This made it difficult to collect data and therefore there was a small response rate (Table 5).

*Table 5.* Answer percentage from the different regions interviewed.

| Study area | Fleet | Members | Answers | Answers rate (%) = (A/M)*100 |
|---|---|---|---|---|
| **NAFO** | Playa de Tambo | 25 | 17 | 68,00 |
| | **TOTAL** | **25** | **17** | **68,00** |
| **Castelló** | Trawling | 56 | 15 | 26,78 |
| | Purse seine | 112 | 15 | 13,39 |
| | Artisanal | 74 | 15 | 20,27 |
| | Pelagic longline | 6 | 1 | 16,67 |
| | **TOTAL** | **248** | **46** | **18,55** |
| **Aegean Sea** | Altınoluk | 117 | 15 | 12,82 |
| | Mordoğan | 65 | 17 | 26,15 |
| | Urla | 33 | 13 | 39,39 |
| | Bostanli | 157 | 13 | 8,28 |
| | Akbük | 11 | 5 | 45,45 |
| | Akyaka | 25 | 17 | 68,00 |
| | Akçapinar | 18 | 5 | 27,78 |
| | **TOTAL** | **426** | **85** | **19,95** |

### 2.3 Data analysis

A total of 29 different indicators were analysed in this study using questionnaires. Indicators are from three different factors: biological, economic and social. Likewise, these factors correspond with the components of the VA respectively (Fig. 8). Each indicator had a certain number (4 mostly) of variables, which were identified by a numerical code. Depending on the degree of vulnerability that represent for the fishing sector they were graduated as follows:

- (1) Very High
- (2) High
- (3) Medium
- (4) Low

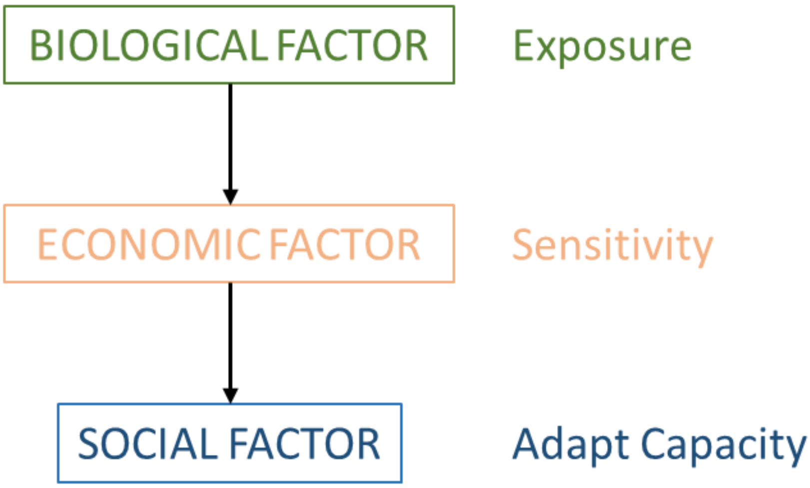


*Figure 8.* Analysed factors equivalent to Vulnerability Assessment components.

The data from the survey questionnaire was coded, inputted and analysed using R and Microsoft Office Excel. The data generated were then used to estimate the vulnerability of three different fishing regions by applying VA.

Having chosen the suitable indicators, it is necessary to ensure that they are standardized. As a next step weights should be assigned to these indicators an appropriate means of creating sub-indices need to be chosen. Since for this research the loadings from the first component of the PCA are used as the weights for the variables and the weighted value for each variable varies between -1 and +1. The sign (+ or -) of the variable indicates the direction of relationship with other variables (Thathsarania and Gunaratneb, 2018). The PCA was run, with the standardized input indicators using "psych" package in the statistical software R-project.

The indicators "Law" and "Primary attention" were removed from the analysis and the indicators "Catch consumption" and "Governmental helps" in the NAFO case study. These indicators were eliminated because they were not correlated with the rest of the indicators. The indicator "Most relevant species" was excluded from the PCA analysis and independently analysed as indicated by the Equation 1.

Equation 1. Indicator = $\sum f \times p$

The indicator was calculated using the product of f (times that fish appears on the answers) among p (ponderation: the fish that the fishermen put on first place have the highest ponderation, 5 to 1 points).

Finally, weight of loadings is not the same in all regions (different data size). For this reason, caution must be exercised when interpreting the results of the PCA. But this study works with the perception from fishermen. Surveys reflect the perspective of fishermen on each region studied.

## 2.4 Vulnerability Assessment

### 2.4.1 Exposure:

The first component to develop VA is Exposure. To calculate the magnitude of Exposure, a numerical value was assigned to each response. Thus, depending on the fishermen's perception, each indicator would have a different degree of threat (understanding values among 1 – 4). 1 being the value that is considered the most serious and 4 the least threatening to their fishing activity. The attribute/factor mean is calculated as the weighted mean of the number of tallies in each scoring bin and the value of each bin (Equation 2; Morrison *et al.,* 2015).

Equation 2. $$E = \frac{(L\ x\ 1)+(M\ x\ 2)+(H\ x\ 3)+(VH\ x\ 4)}{L+M+H+VH}$$

Where,

E = Exposure

L = number of responses to the least threat indicator

M = number of responses to the moderate threat indicator

H = number of responses to the high threat indicator

VH = number of responses to the most threatening indicator

The indicators to measure Exposure are divided in five, each indicator contains a total of four different variables (except “Catch composition” that contains two):

- Climate factors: tries to identify which of the four environmental variables is the most damaging to fishermen.
- Change species: is responsible for assessing the change of species on the sea bed over the past two decades.
- Catch composition: shows the species caught by fishermen and the changes that have occurred in recent decades.
- Catch size: indicates the fluctuation of catches in recent years.
- Fish size: indicates the fluctuation in the size of fish caught in recent years.

These Exposure factors could include changes in means or changes in variability depending on what is appropriate for the region (Morrison *et al.,* 2015).

### 2.4.2 Sensitivity:

The second component to develop VA is Sensitivity. Using equation 3 is possible calculate the magnitude of Sensitivity. Value assignment is the same like in the case of Exposure.

$$\text{Equation 3. } S = \frac{(L\ x\ 1)+(M\ x\ 2)+(H\ x\ 3)+(VH\ x\ 4)}{L+M+H+VH}$$

Where,

S = Sensitivity

L = number of responses to the least threat indicator

M = number of responses to the moderate threat indicator

H = number of responses to the high threat indicator

VH = number of responses to the most threatening indicator

The indicators to measure Sensitivity are divided in eight, each indicator contains a total of four different variables (except “Fishing modality” that contains two):

- Fishing revenues: determines the percentage of income that fishermen receive directly from their profession.
- Other revenues: determines the percentage of income that fishermen receive from other non-fishing activities.
- Catch consumption: indicates the percentage of catches consumed by fishermen and their families.
- Fishing modality: denotes whether fishermen have changed their fishing gear in the last decade.
- Change modality: shows why fishermen switched from using one gear to a different one.
- Labour opportunities: it reflects the employment possibilities of fishermen in the event that they have to give up their trade.
- Economic helps: shows whether fishermen are remunerated economically from any other source.
- Governmental helps: shows whether fishermen receive any kind of financial compensation from the government.

### 2.4.3 Adaptive Capacity:

The third and last component to develop VA is Adaptive Capacity. Using equation 4, Adaptive Capacity can be obtained.

Equation 4. $AC = \frac{(L \ x \ 1)+(M \ x \ 2)+(H \ x \ 3)+(VH \ x \ 4)}{L+M+H+VH}$

Where,

AC = Adaptive Capacity

L = number of responses to the least threat indicator

M = number of responses to the moderate threat indicator

H = number of responses to the high threat indicator

VH = number of responses to the most threatening indicator

The indicators to measure Adaptive Capacity are divided in fourteen, each indicator contains a total of four different variables (except “Administrative requirements” that contains 2):

- Administrative requirements: reflects changes in conditions in the fisheries sector over the last twenty years.
- Family size: shows the number of members of a fisherman's family.
- Professional education: indicates the way in which the fisherman learned to fish.
- Available education: indicates whether it is possible to study another trade.
- Formal education: indicates the academic level of training.
- Share information: assesses fishermen's confidence in sharing information with fisheries authorities.
- Good laws: values the level of confidence of fishermen in the fisheries authorities.
- Government interest: seeks to determine the level of attention paid by fisheries authorities when fishermen report an event at sea or within the fishing sector.
- Law application: reflects fishermen's perception of law enforcement.
- Change laws quickly: tries to determine whether fisheries authorities can deal with new situations quickly.
- Transparency: shows whether the law is transparent or not.
- Primary attention: shows access by fishermen and their families to primary health care.
- Insurance: indicates whether or not fishermen have life insurance for their family members in the event of death.
- Age: reflects the year’s fishermen have been working in the sector.

### 2.4.4 Vulnerability:

The overall vulnerability rank is determined by using the following equation 5 Adger and Vincent, 2005) to create an overall metric of vulnerability (Cinner *et al*., 2012). A quantitative vulnerability score was developed using equation to combine the three components (each normalized to 1-4 scale). The product is then classified with a numerical index (Table 6). The Vulnerability Assessment score shows the level of vulnerability present on each region studied.

Equation 5. $V = (E + S) - AC$

*Table 6.* The levels of Vulnerability based on the ranges of index scores.

| Level of V | VA score range |
|---|---|
| High | 1.00 – 2.00 |
| Moderate | 2.01 – 3.00 |
| Low | 3.01 – 4.00 |

Thanks to the equation, it has been possible to make a quantitative assessment of the components. But, Exposure, Sensitivity and Adaptive Capacity can have a number of social and psychological dimensions that cannot be encompassed (Marshall and Marshall, 2007) using this formula.

# 3 RESULTS

The results show the differences and similitudes between three different fishing regions: NAFO (industrial fleet), Castelló and Aegean Sea (SSFs).

## 3.1 Factors Analysed

### 3.1.1 Exposure:

“Climate factors”, “Catch size” and “Fish size” are perceived by the different studied areas as the greatest threats to their activity. In all cases “Catch composition” represents the lowest threat. All areas are similarly exposed to threats caused by the biological factor (Table 7). The two most relevant climatic factors identified as threats by fishermen were, firstly, storms and, secondly, temperature (Fig. 9). Fishermen of the Aegean Sea and artisanal fleet of Castelló indicated that storms are the climatic factor that affects their fishing activity the most.

*Table 7.* Component matrix for Biological factor.

| **Indicators** | | **PC1** | |
|---|---|---|---|
| | NAFO | Castelló | Aegean |
| **Climate factors** | 0.69 | 0.78 | -0.65 |
| **Change on species** | -0.54 | 0.34 | -0.18 |
| **Catch composition** | -0.08 | -0.25 | 0.25 |
| **Catch size** | -0.66 | -0.31 | 0.75 |
| **Fish size** | 0.65 | 0.81 | 0.61 |

On the one hand, Temperature and Storm are the two climate factors that fishermen of Castelló perceive that they may affect their fishing activity. Storms are the climate factor that affect more directly to the Artisanal fleet. However, Temperature affects more Purse-seine and Trawling fleets. On the other hand, Storm is the climate factor that Turkish fishermen perceive that affect their fishing activity the most. In spite of that on north to south regions they showed that temperature is the second climate stressor that affects their fishing activity.

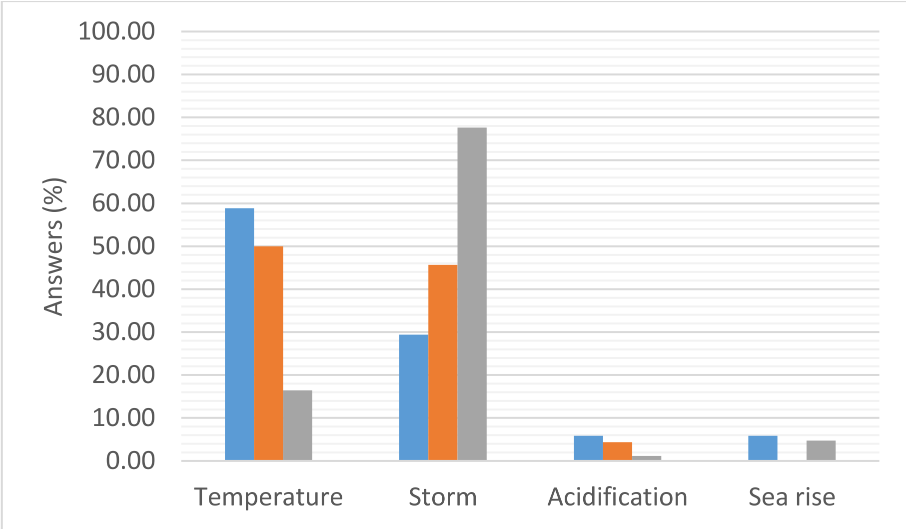


*Figure 9*. Percentage of answers to Question 1) Which climate stressor will affect fish and your fishing the most? ***Blue***: *NAFO,* ***Orange***: *Castelló and* ***Grey***: *Aegean.*

The top five fish species (Table 8) represent, according to the fishermen, their highest income, wich are therefore at high risk. The most relevant species vary according to the type of fleet and the region in which it is found. Even within the same region where a fleet with similar characteristics operates. Each fisherman that was interviewed affirmed that there were species that yielded higher incomes than others.

*Table 8.* Answers to Question 5) What top five fish species do you harvest?

| ***Location*** | **Fleet/Region** | **Specie 1** | **Specie 2** | **Specie 3** | **Specie 4** | **Specie 5** |
|---|---|---|---|---|---|---|
| *NAFO* | Average | Greenland halibut | Redfish | Hake | Pink hake | Cod |
| *Castelló* | Artisanal | Axillary seabream | Amberjack | Zebra seabream | Sea bream | Dentex |
| | Purse seine | Anchovy | Sardine | Chub mackerel | Atlantic mackerel | Horse mackerel |
| | Trawling | Hake | Striped red mullets | Cuttlefish | Monkey fish | Octopus |
| *Aegean sea* | South | Sea bass | Sea bream | Red porgy | White grouper | Bonito |
| | Central | Sea bream | Mullet | Sand Steenbras | Sea bass | Horse mackerel |
| | North | Sea bream | Red mullets | Mullet | Octopus | Cuttlefish |

On the one hand, the species that fishermen harvest have not changed in the last ten years. At least that is how it is been for NAFO. On the other hand, in both Castelló and Aegean Sea fisheries there is a small discrepancy. 10 % of the fishermen indicate that species changed in the case of Castelló and 30 % in the case of Aegean Sea (Fig. 10). According to Castelló fishermen species like Zebra seabream (*Diplodus cervinus*), Amberjack (*Seriola dumerili*) or Sea bream (*Sparus aurata*) are no longer present or their populations have decreased dramatically.

In case of Aegean Sea, a lot of species are replaced by lessepsian species (Fig. 11). Species like Sea bass (*Dicentrarchus labrax*), Mullets (*Liza* spp.) or Cuttlefish (*Sepia officinalis*) are no longer present and in their place appear, aside invasive species, Red mullets (*Mullus barbatus*), Sand Steenbras (*Lithognathus mormyrus*) and prawns (*Penaeus japonicus*). In central and northern regions, the majority of fishermen percived that the species that they harvest have not changed in the last 20 years. However, the southerb region is more divided, only a few fishermen consider that fishes have changed.

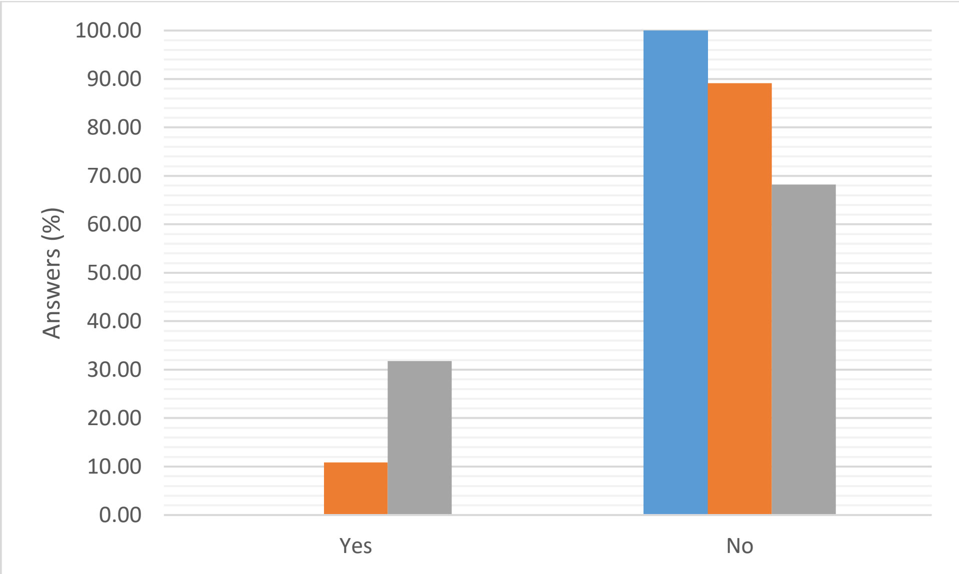


*Figure 10.* Percentage of answers to Question 8) Have the species you harvest changed in the last 10 years? If so, from what to what? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

In Turkey, unlike Spain, a large number of invasive species have appeared, such as *Nemipterus randalli* (Japanese threadfin bream; Fig. 11a), *Saurida undosquamis* (Brush tooth lizard fish; Fig. 11b), *Siganus* spp (Rabbit fishes; Fig. 11c) and *Lagocephalus sceleratus* (Silver-cheeked toadfish; Fig. 11d).


*Figure 11 Invasive fish species in Aegean Sea (Akyaka Fishing Cooperative, Gökova Bay, Turkey): a) Nemipterus randalli, b) Saurida undosquamis, c) Siganus rivulatus (Source: Dammous, S.) and d) Lagocephalus sceleratus.*

There are not big changes in the case of fishermen catch composition during the last decades. However, it is true that some of the fishermen's population has perceived alterations (Fig. 12). For example, some fishermen from the trawling fleet of Castelló detected an increased presence of Deep-water rose shrimp (*Parapenaeus longirostris*) instead of Blue whiting (*Micromesistius poutassou*). In the same region but different fleet, the purse-seine fleet emphasised that population of Sardines (*Sardina pilchardus*) and Anchovies (*Engraulis encrasicolus*) are inverted. In other words, Sardine populations used to predominate the catch composition before, but nowadays Anchovy is more abundant. Another example, in the case of Urla fishermen (central Aegean Sea) there are many species that no longer dominate the catch. The species taht used to dominate were Sand Steenbras (*Lithognathus mormyrus*), Sea bream (*Sparus aurata*), Red mullets (*Mullus barbatus*) and Horse mackerels (*Trachurus trachurus*).

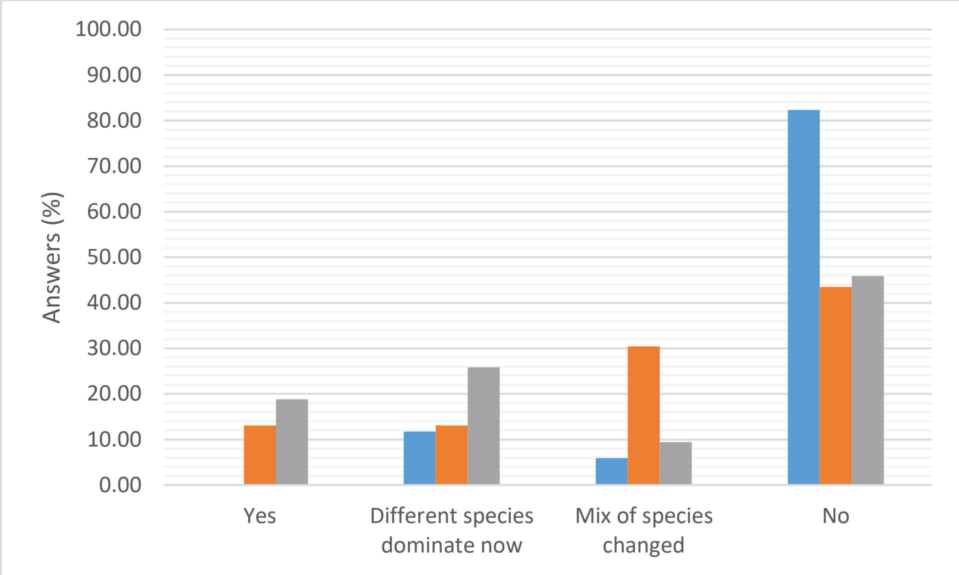


*Figure 12.* Percentage of answers to Question 9) Has your catch composition changed in the last (two) decades? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

Almost 70 % of Aegean fishermen agree that their total catches have decreased in the last two decades. A smaller percentage of fishermen from the NAFO fleet as well as the different Castelló fishing fleets are of the same opinion. However, in the case of these two regions, half of the fishermen are of the opinion that there has been no change in their total catches. Only a few fishermen consider that their catches have increased in recent decades (Fig. 13).

In the particular case of Castelló, both the Minor Gear fleet and the Purse seine fleet perceive a decrease in total kilos currently landed. However, the responses of the trawl fleet are more diverse. The majority of trawlers from the Port of Castelló reflected that the amount of fish currently caught is greater than it was years ago.

Fishermen from the central and north Aegean Sea regions are almost 100 % sure that total catch decreased in the last two decades. The southern region is more divided. Most people think that there are no changes and more or less the same people consider that total catch has decreased. However, 25 % of fishermen from this regions perceived that total catch has increased.

In all cases most fishermen responded that the size of the fish had not changed in the last two decades. In the case of Aegean Sea the perception of the size of the fish that they harvest is similar between the decline of the fish and the fact that their size has not changed (Fig. 14).

However, most fishermen in all fleets agree that the size of the fish has decreased. Few others consider that there have been no changes. And a minority do perceive a larger size of fish that are caught. The majority of fishermen agree that the size of fishes that they catch has not changed or decreased. Like before, few fishermen from the southern region perceived increasing fish size.

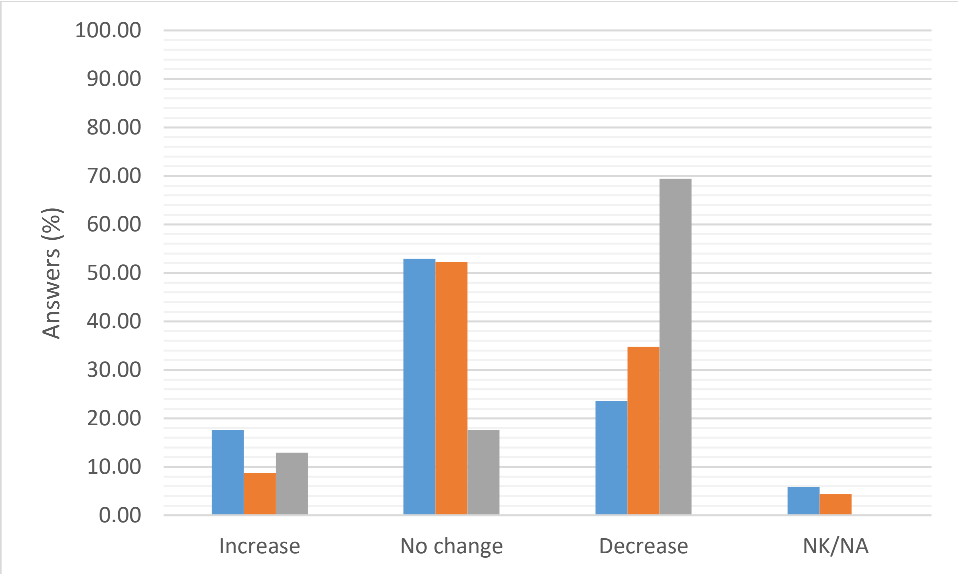


*Figure 13.* Percentage of answers to Question 10) Has your total catch increased, been stable or decreased in the last (last two) decade(s)? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

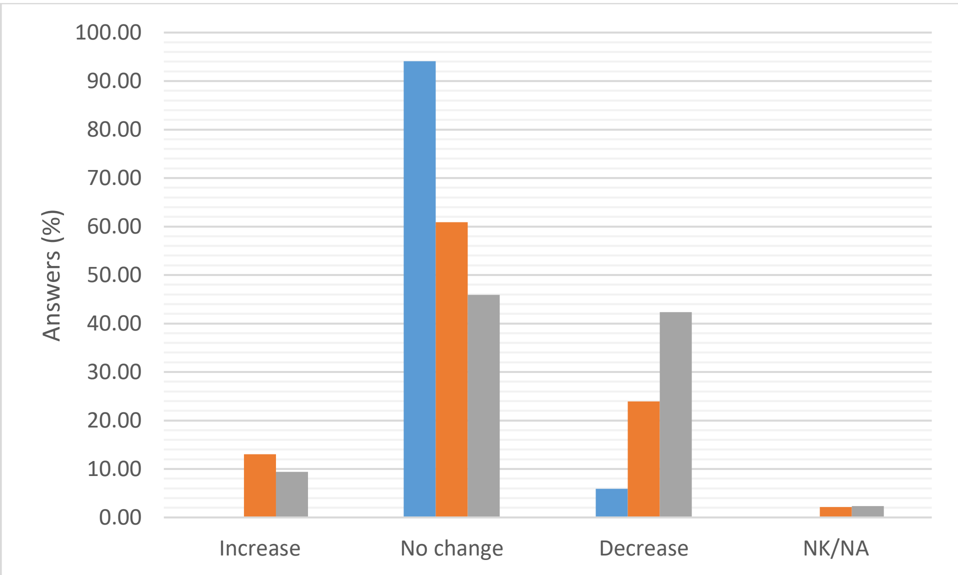


*Figure 14.* Percentage of answers to Question 11) Has the size of the fish that you harvest changed in the last decade or two? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

### 3.1.2 Sensitivity:

Both, "Fishing revenues" and "Other revenues" are perceived as the indicators most sensitive to threats in the fishing sector by the different fishing regions NAFO and Aegean. In parallel, "Fishing modality" and "Change modality" are the indicators which the Castelló region considers to be the most susceptible in the same way as the fleet operating in the NAFO area (Table 9).

Almost all of NAFO and Castelló fishermen generate their income directly from fishing. Unlike the fishermen of the Aegean region (Fig. 15). Only a few fishermen in the south and central regions earn income directly from fishing. The majority of fishermen on the Aegean Sea complements their incomes with other jobs, whether they are: taxi drivers, street vendors, maintenance managers, etc. (Fig. 16). For this reason, some fishermen's income is less than 50 % from fishing activities. However, all the income of all the fishing fleets that operate in the Port of Grao de Castelló comes from fishing activity. Consequently, they have no other means to generate income.

Moreover, fishermen of the Aegean region are the ones who consume the most fish from their catches. They can consume more than 20 % of their catches annually. In contrast with the other two sampled regions, which consume only less than 5 % (Fig. 17). Around 60 % of fishermen from the southern region consume less than 5 % from their catch. In comparison with other regions, this percentage is reduced to 50 %. There are a lot of fishermen from the three regions that eat 10 % from their catch. Lastly, few fishermen (most from central region) consume more than 15 % from their catch.

*Table 9.* Component matrix for Economic factor.

| **Indicators** | | **PC1** | |
|---|---|---|---|
| | NAFO | Castelló | Aegean |
| **Fishing revenues** | -0.85 | 0.62 | -0.88 |
| **Other revenues** | 0.85 | -0.15 | 0.90 |
| **Catch consumption** | - | 0.02 | 0.36 |
| **Fishing modality** | -0.85 | -0.84 | 0.20 |
| **Change modality** | 0.85 | 0.87 | -0.32 |
| **Employment opportunities** | 0.29 | 0.09 | -0.31 |
| **Economic helps** | -0.15 | 0.46 | 0.10 |
| **Governmental helps** | - | -0.54 | 0.50 |

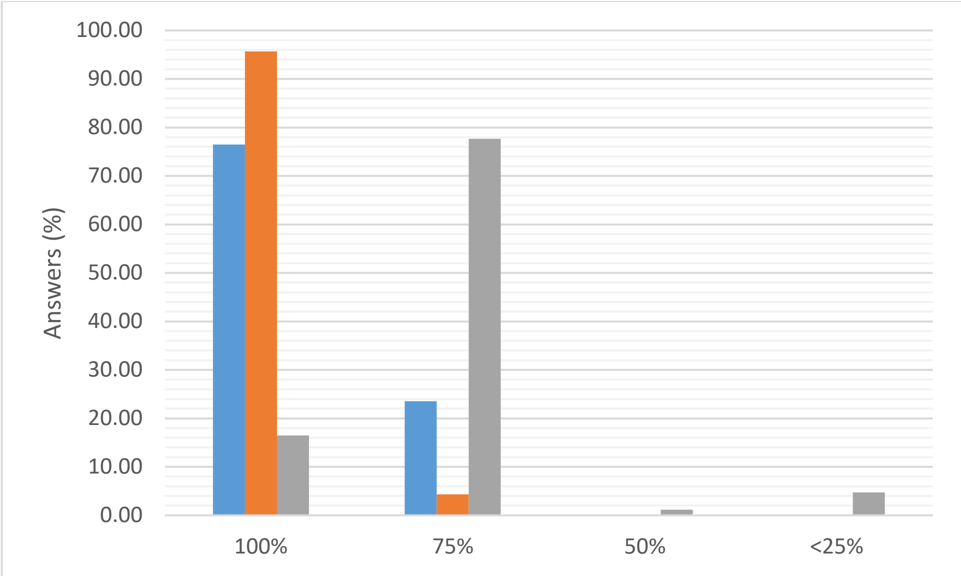


*Figure 15.* Percentage of answers to Question 2) How much of your income (percent) comes from fishing? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

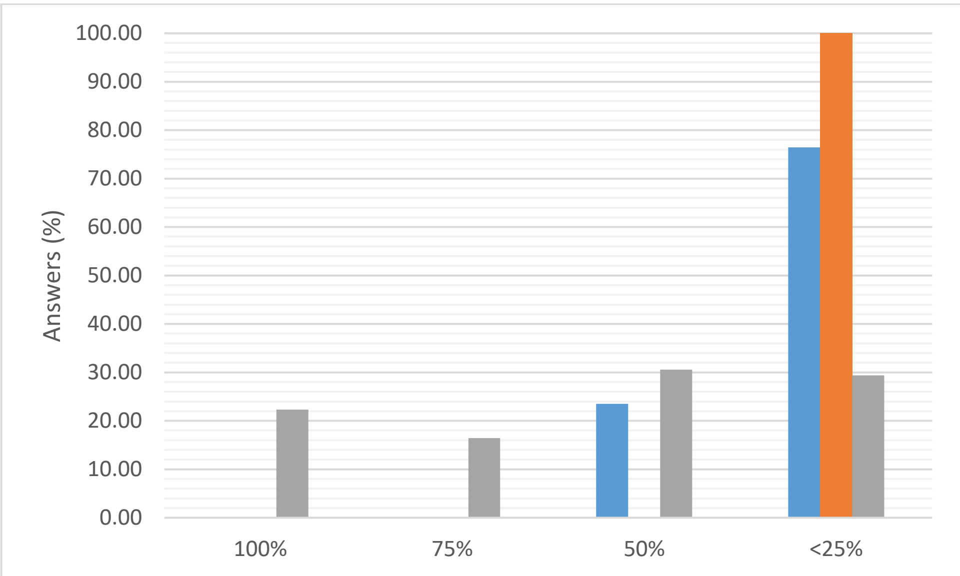


*Figure 16.* Percentage of answers to Question 3) How much income do you receive from other activities than fishing? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

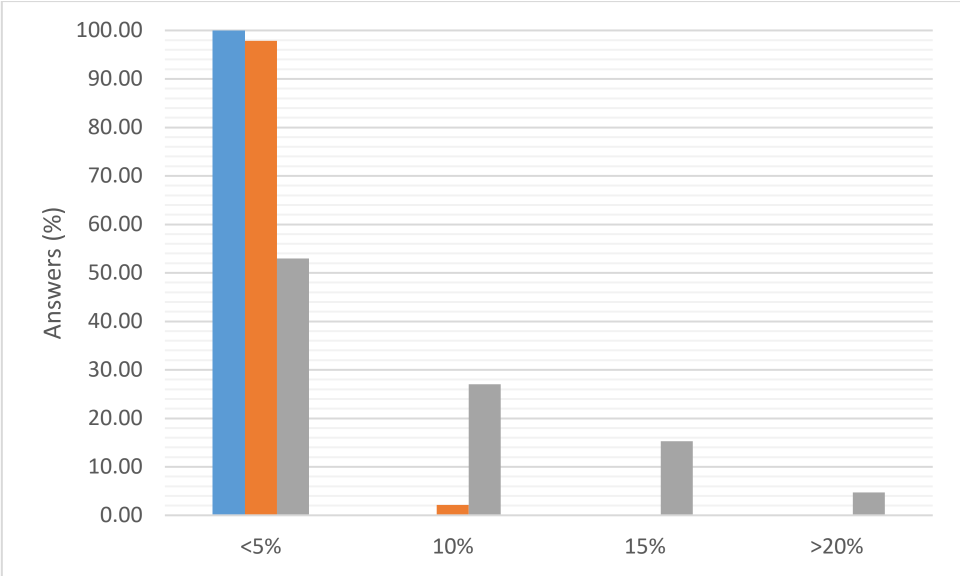


*Figure 17.* Percentage of answers to Question 4) How much of your catch do you, your family(ies) and friends consume? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

In all regions, the majority of fishermen have continued to fish with the same gear that they have always used to carry out their daily fishing activity (Fig. 18). In the case of Castelló, those who did were, for the most part, trawlers. In the case of Aegean region, around 40 % of fishermen changed their gear in the last 10 years, and 60 % didn't do it. The majority of fishermen who changed their gear were from the northern region.

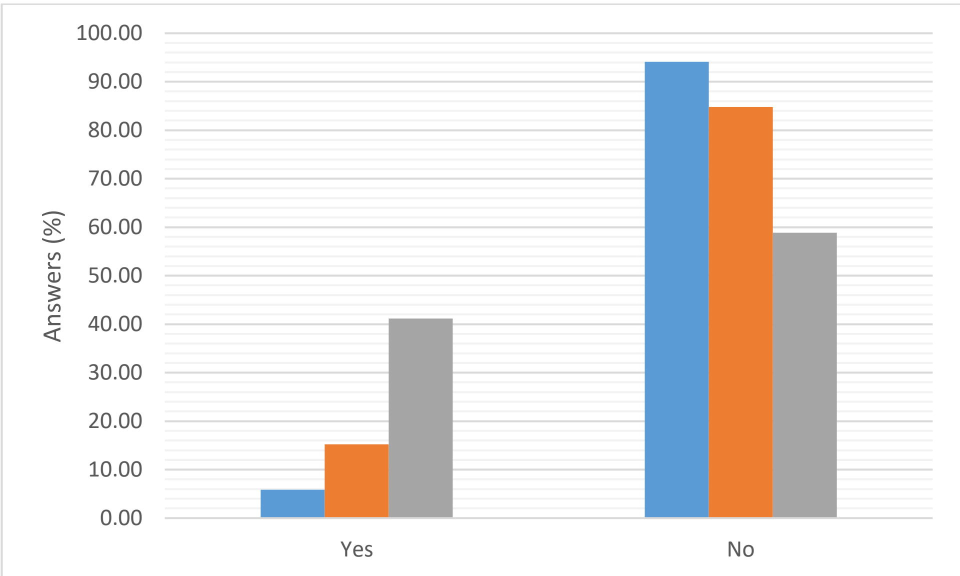


*Figure 18.* Percentage of answers to Question 6) Have you changed your fishing gear in the past 5 – 10 years? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

The reasons why fishermen have decided to change gear in recent years are very diverse. Although most began to use different arts by changes in law or regulations, change in conditions at sea, practical reasons (maintenance problems, worn out, old, could not replace, hard to use) and safety (Fig. 19).

In Castelló, everyone agrees that they have changed due to breakage and technical problems of the rigging and change in the target species. Except the representative of the surface fishers who clarified that it changed its gear due to a modification of the existing regulation. North Aegean region fishermen changed their fishing modality from long line to gillnet or vice versa. Most of fishermen from the southern region that change their gear did it because the fishing regulations or the conditions at the sea are different. However, in the northern region they changed gear for labour or economic reasons.

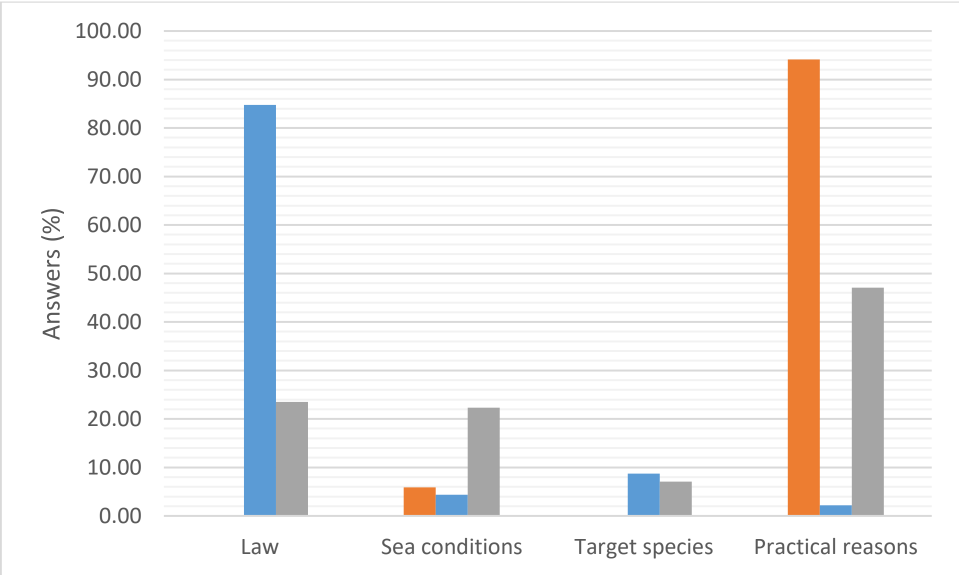


*Figure 19.* Percentage of answers to Question 7) If you have changed your fishing gear in the last decade, why did you do that? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

If they could no longer go fishing, fishermen explained what their future trade might be. Few people choose to continue working at sea, but this time in aquaculture. Only around 20% of the fishermen interviewed in the Aegean would be willing to do so. A greater number of fishermen responded that if they stop working at sea, their options could be to move to agriculture or to another region to find a new job. Most fishermen replied that if they stopped fishing they would retire (given the age of many of them), especially in the case of Castelló and north Aegean fishermen. However, some fishermen also had the possibility of working in the business of a relative or even creating their own business (Fig. 20).

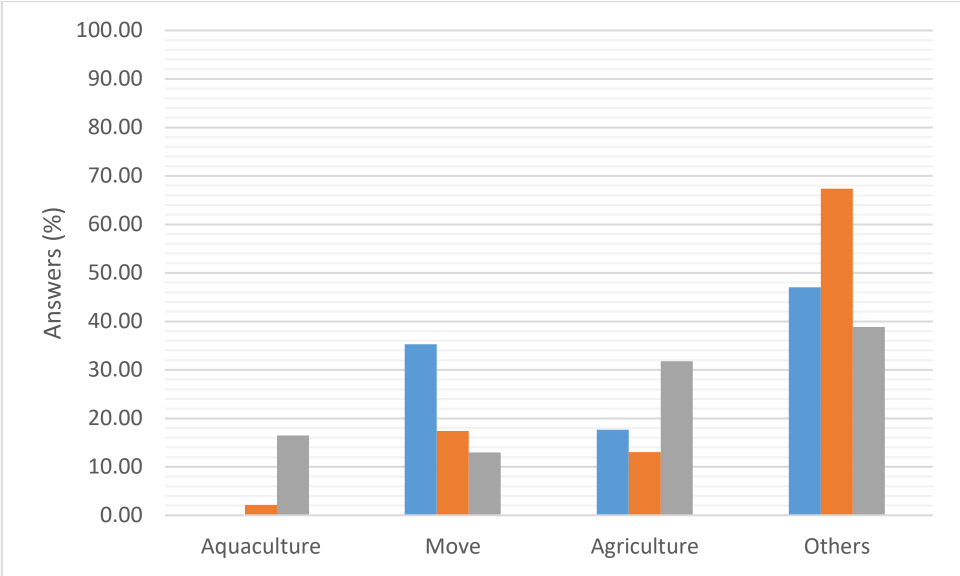


*Figure 20.* Percentage of answers to Question 12) What choices do you have if you cannot (or are not allowed to) go fishing anymore? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

On the one hand, without counting the money they earn from their profession, fishermen do not receive any other kind of private financial assistance (Fig. 21). On the other hand, they do receive financial assistance from the government. In the case of NAFO fishermen, this aid covers 100 % of their income if their fishing is reduced. For inshore fleets, such as Castelló and Aegean, the government does not provide any help if they see their catches dwindling. Or if there were aid, it would only cover less than half of their expenses (Fig. 22). With the exception of the Purse seine fleet, they responded that they did receive a percentage of income from the government.

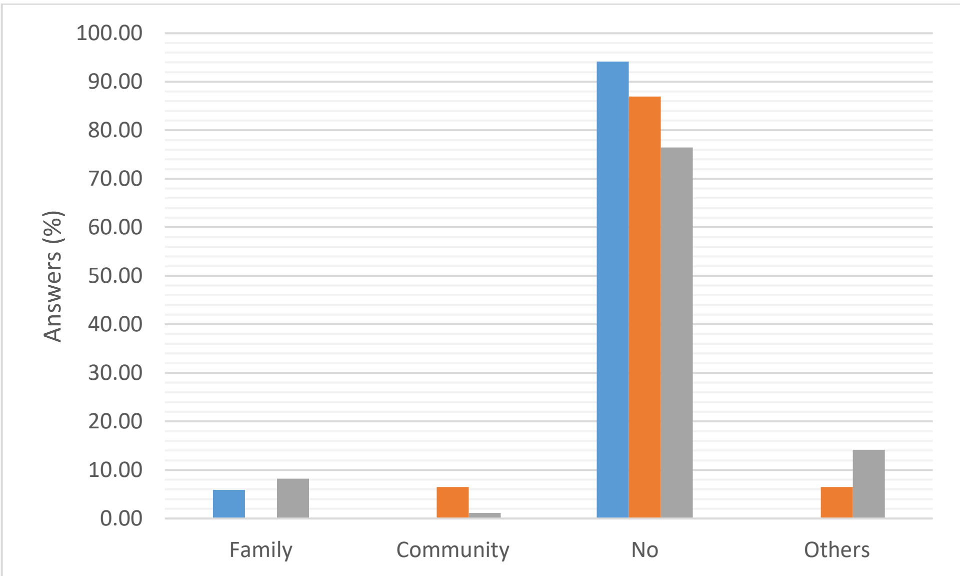


*Figure 21.* Percentage of answers to Question 13) Do you get financial help from private sources such as your family, friends or communities? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

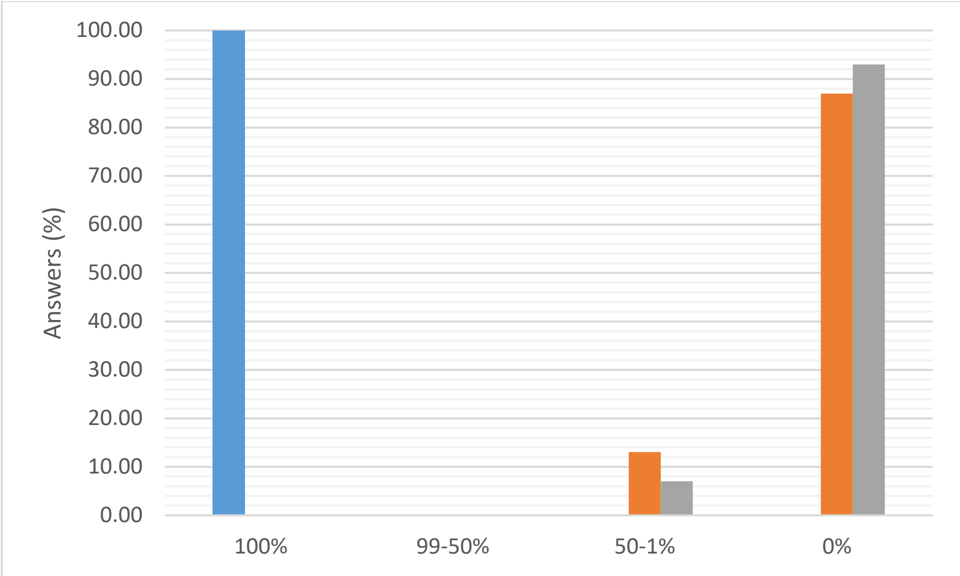


*Figure 22.* Percentage of answers to Question 14) Do you get compensation from the government if your income from fishing is reduced? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

### 3.1.3 Adaptive Capacity:

Each region considers different measures according to the needs of their fishermen. In the case of NAFO, the loading for “Share information” indicator has presented higher positive values out of all indicators. The opportunity for fishermen to have simple lines of communication with fisheries institutions provides a great opportunity for AC. “Available education” and “Formal education” are the other two indicators that represents the highest AC in the NAFO area. In the case of Castelló, “Transparency” and “Insurance” are the indicators that guarantee that fishermen continue to carry out their fishing activity. At the same time, “Professional education” and “Formal education” represent a great opportunity for the future of the fisheries sector in this region. Finally, in the Aegean Sea, “Change law quickly” enables the fisheries administration to deal with new threats faster. In this way, they increase AC. “Insurance” and “Good laws” are the other two indicators to be promoted in order to obtain a better AC (Table 10).

Both NAFO area and Castelló fishermen reflected that they had noticed changes in their fishing practices. However, the opinion of the Aegean fishermen is almost equally divided (Fig. 23). In all cases, the fishermen who answered “Yes” agree on the same thing. The changes that have taken place in their daily fishing activity are, for the most part, changes of a bureaucratic nature. According to the fishermen, “there is now much more control and inspection than before”. “You continuously have to have more documents in order”. “We must continually be training in new courses”. “Before, going out to sea and knowing how to swim was enough, sometimes not even that”. “Today, in addition to the vein sheets there is the electronic logbook (DEA)”. Fishermen who answered “NO” despite their response, have perceived the changes in a similar way to their peers who answered yes. “Only Basic Safety Training is required”. “The conditions are the same, perhaps a little more bureaucracy”.

*Table 10.* Component matrix for Social factor.

| Indicators | PC1 | | |
|---|---|---|---|
| | NAFO | Castelló | Aegean |
| **Administrative requirements** | -0.37 | 0.09 | -0.25 |
| **Family size** | -0.41 | -0.35 | -0.34 |
| **Professional education** | 0.47 | 0.70 | -0.04 |
| **Available education** | 0.71 | 0.41 | -0.26 |
| **Formal education** | 0.67 | 0.66 | -0.02 |
| **Share information** | 0.84 | 0.35 | 0.43 |
| **Good laws** | 0.56 | 0.44 | 0.68 |
| **Law enforcement** | 0.62 | 0.12 | 0.63 |
| **Government interest** | 0.14 | 0.11 | 0.43 |
| **Change law quickly** | 0.42 | -0.09 | 0.81 |
| **Transparency** | 0.56 | 0.88 | 0.62 |
| **Insurance** | 0.50 | 0.81 | 0.73 |
| **Age** | -0.37 | 0.41 | 0.49 |

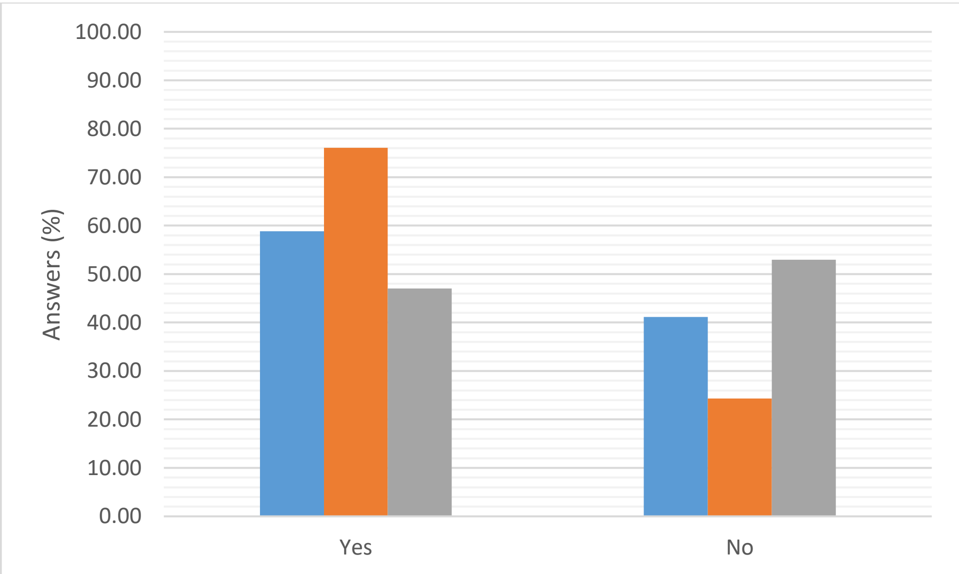


*Figure 23.* Percentage of answers to Question 15) Have you experienced changes in fishing as an activity **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

Most fishing families are large families, made up of 5 members. This is the case for the fishermen of NAFO and Castelló where almost 50 % of the families fulfil these characteristics. In the case of the Aegean, there is more diversity in the number of members that make up the household (Fig. 24).

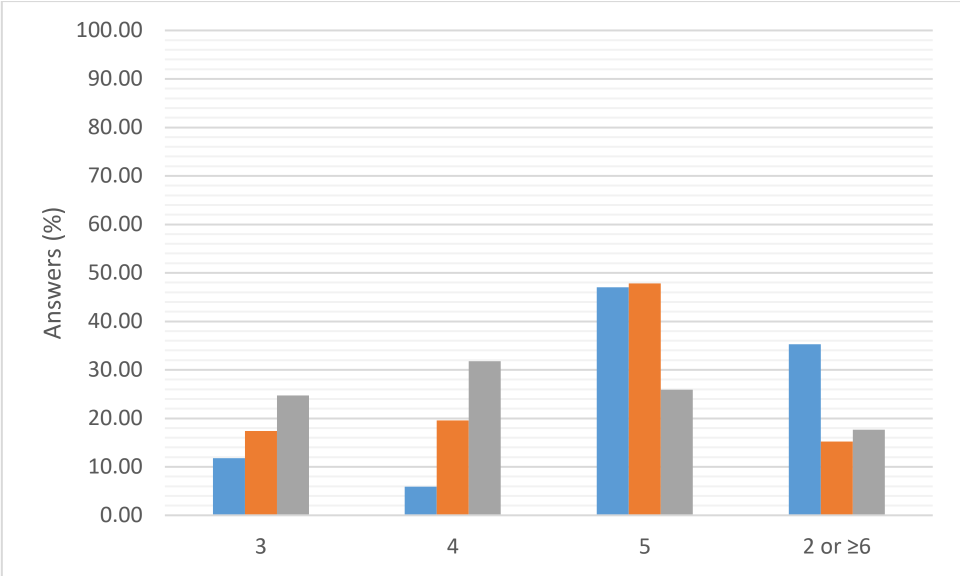


*Figure 24. Percentage of answers to Question 16) What is your family size (including yourself, wife or husband, your children)?* **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

Fishermen who fish in artisanal fleets, such as those of Castelló and the Aegean Sea, learned to fish for themselves or by family tradition (their fathers and grandfathers taught them). In the case of NAFO, a lot of fishermen received formal training for some kind of marine schools. (Fig. 25). On the one hand, most purse seiners from Castelló learned the fisherman's profession by family tradition, inherited from their parents and grandparents. However, most of the fishermen in the trawl fleet learned the trade in the maritime-fishing school. On the other hand, the majority of fishermen from the north Aegean region learn the office from their parents. In contrast with fishermen from south and central regions that learn by themselves.

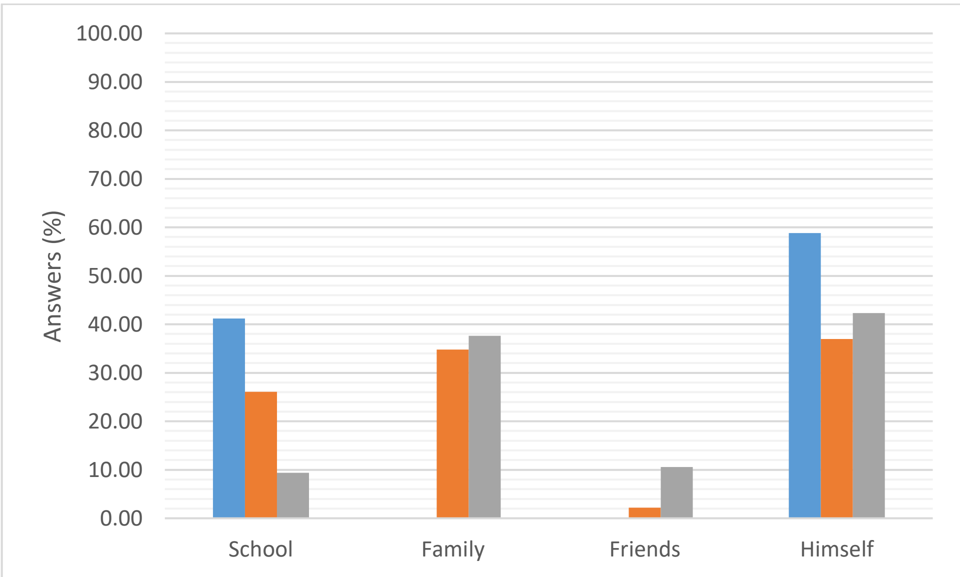


*Figure 25.* Percentage of answers to Question 17) Have you received formal or informal training in your profession? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

According to the fishermen, if they wanted to change to another profession, there is no training available. And if they are interested in learning a new profession they must pay the cost by themselves (Fig. 26).

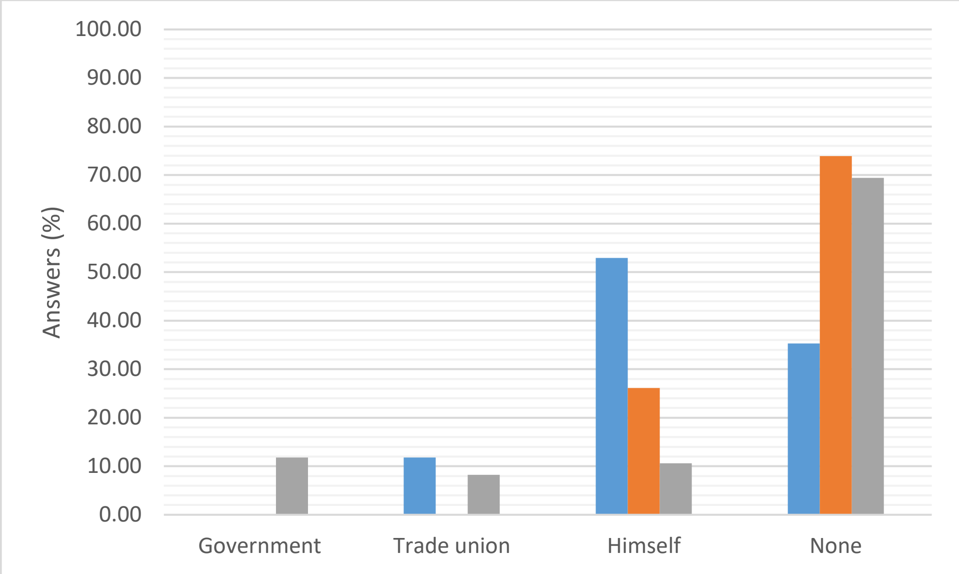


*Figure 26.* Percentage of answers to Question 18) Is training available if you want to change professions? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

In most cases, the level of formal education of fishermen is really low. Many fishermen do not get passed Primary School and many others have never been schooled. This data is more striking in artisanal fleets. The Aegean region has the highest percentage of fishermen with a higher formal education, especially from the north region. Only a few fishermen studied at college (Fig. 27).

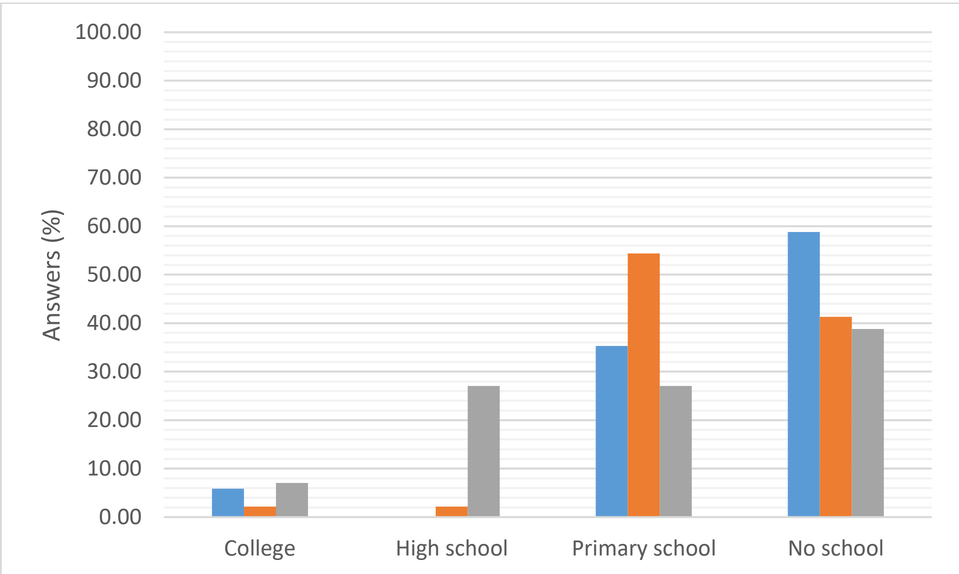


*Figure 27.* Percentage of answers to Question 19) What is your highest formal education? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

The majority of fishermen from Aegean Sea fleets feel that they can share information with fishing authorities.  Fishermen perception is divided in Castelló, regardless of the type of fleet in which they operate. Among those who believe that information can be shared with the fisheries authorities and among those who believe that they cannot. In the case of NAFO many of them do not know what to answer (Fig. 28).

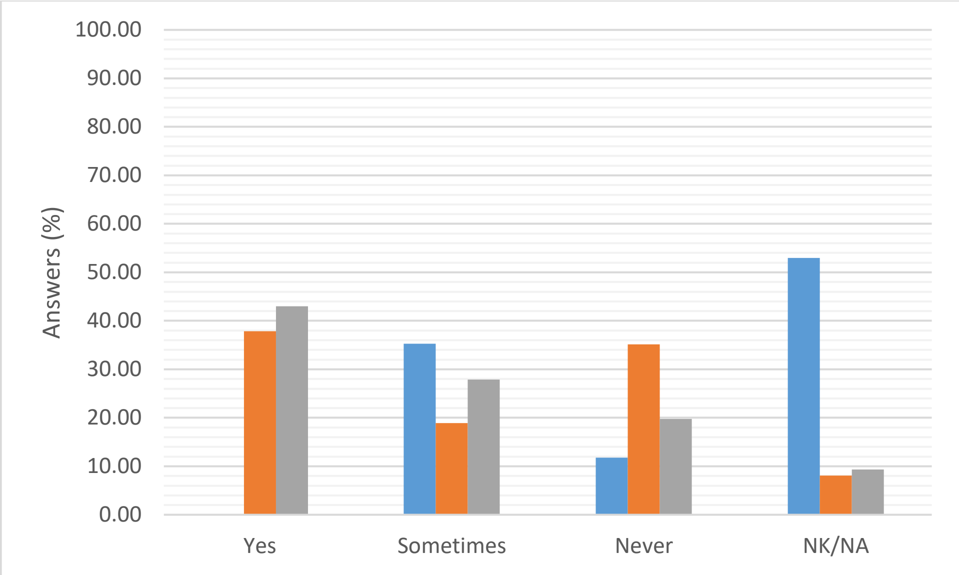


*Figure 28.* Percentage of answers to Question 20) Do you feel you can share information with fishing authorities? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

In all regions, the majority of fishermen considers that authorities do not have the capacity to determine good rules for fishing. There is another sector that considers they are good at some things but not at others, or they are competent but unable to make decisions (Fig. 29). In the particular case of Castelló, opinions differ as to whether the authorities determine good rules for fishing. In terms of misperception by the artisanal fleet, south and north Aegean regions believe that fishing authorities are good at some things but not others. In contrast with the central region that mostly thinks that they are generally incompetent and can never make a decision.

The opinion of fishermen about the adequate enforcement of the rules is very diverse. Most of them believe that there is no enforcement at all. Above all, in the south and north Aegean region fishermen perceive that rules and regulations are usually or sometimes enforced. In contrast with the central region, that thinks that the laws are inadequately enforced or there is no enforcement at all. Fishermen from NAFO and Castelló perceive predominantly that rules and regulations are usually enforced (Fig. 30), especially on artisanal and trawling fleets.

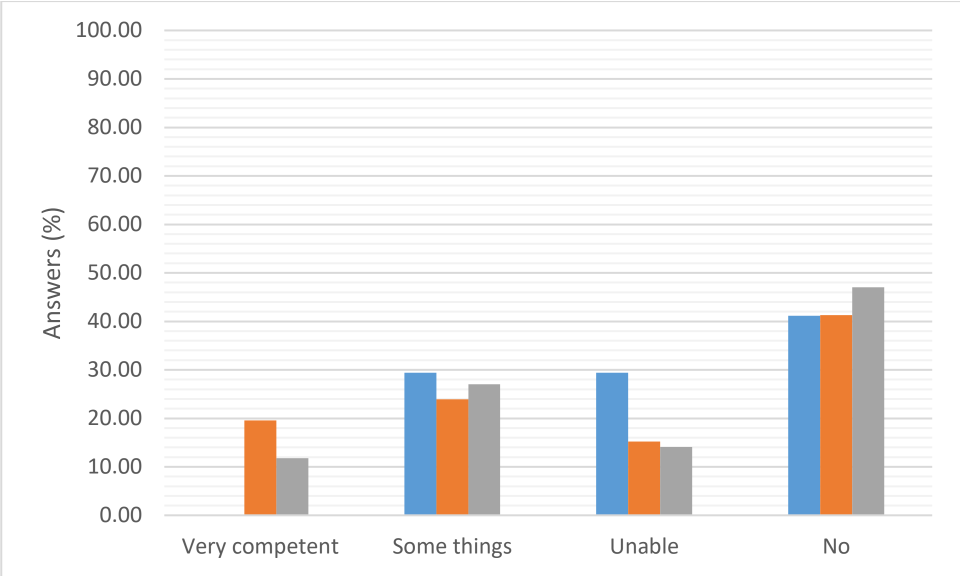


Figure 29 Percentage of answers to Question 21) Do you feel authorities have the capacity to determine good rules for fishing? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

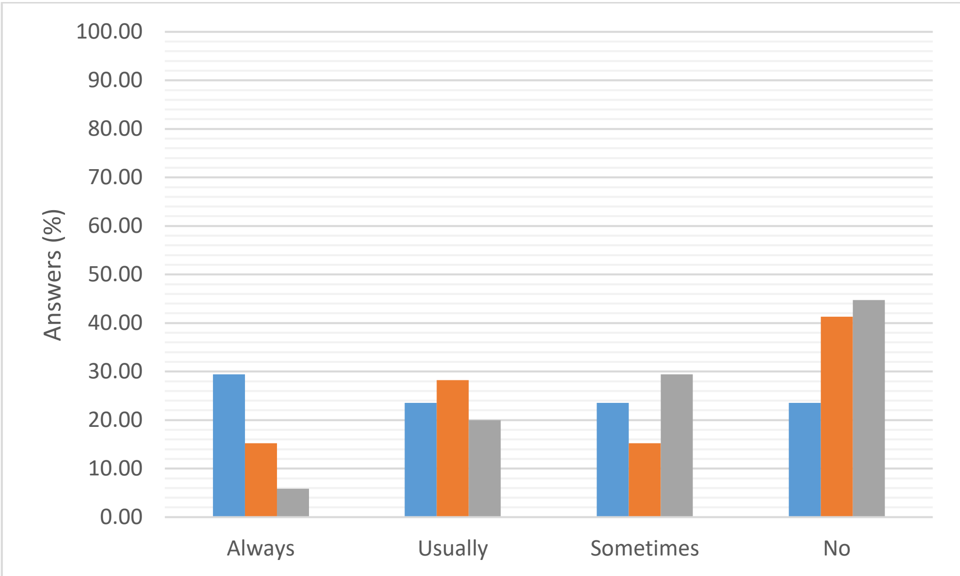


*Figure 30.* Percentage of answers to Question 22) Is there adequate enforcement of the rules/laws/regulations? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

In all regions visited, fishermen consider that fishing authorities very rarely listen, to them when they report on fish or fishing (Fig. 31). On the one hand, in Castelló, both SSF and trawl fleets consider that the fisheries authorities do not listen to them. The purse seine fleet differs from this response. On the other hand, according to the Aegean fishermen, fishing authorities never or few times listen to them when they report something about fish or fishing.

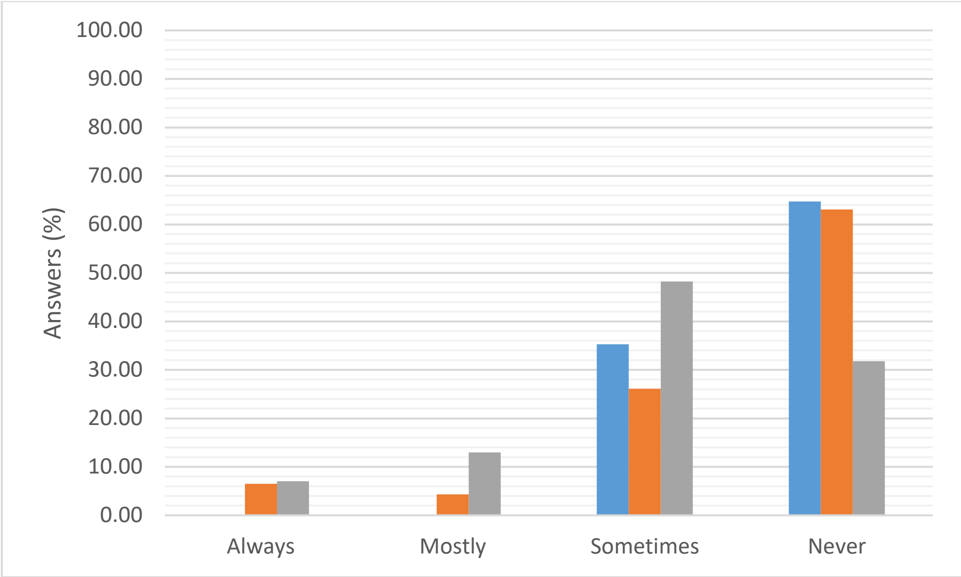


*Figure 31.* Percentage of answers to Question 23) Do (fisheries authorities) listen to you when you report on fish or fishing? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

According to the fishermen, fishing authorities do not apply the rules fairly at all. Very few fishermen consider that fishing authorities apply them fairly. (Fig. 32). Castelló is the region where fishermen feel that the rules are most unfairly applied. According to the artisanal fishermen, the application of the law is not fair. There is a discrepancy between the purse seine and trawl fleets. There are those who consider that it is applied and those who consider that the law is not applied.

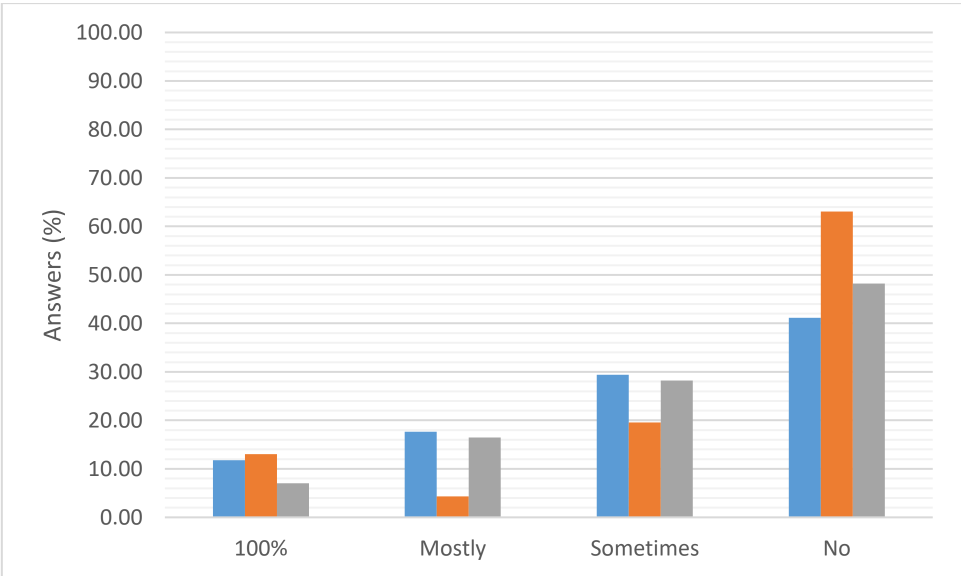


*Figure 32.* Percentage of answers to Question 24) Do fishing authorities apply the rules fairly? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

In the event of a situation requiring rapid intervention by the fisheries authorities, the perception are very different but fishermen mostly consider that the rules cannot be changed fast enough to respond to these new situations (Fig. 33).

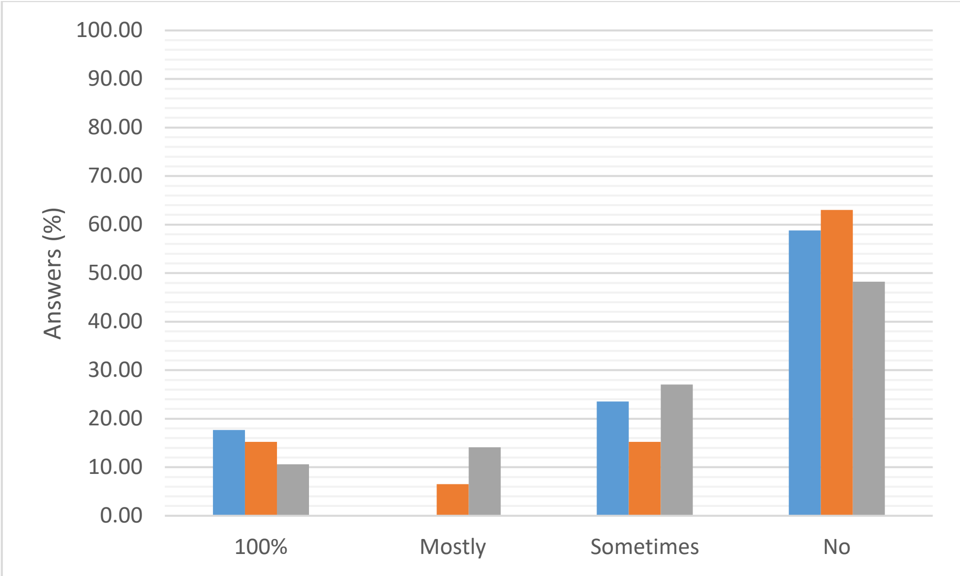


*Figure 33.* Percentage of answers to Question 25) Can authorities change rules quickly to respond to new situations? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

70% of Castelló's fishermen consider that the decision-making by the authorities is open (transparent). In contrast with NAFO and Aegean Sea fishermen where the majority believe that the decision-making process not clear or not open at all (Fig. 34).

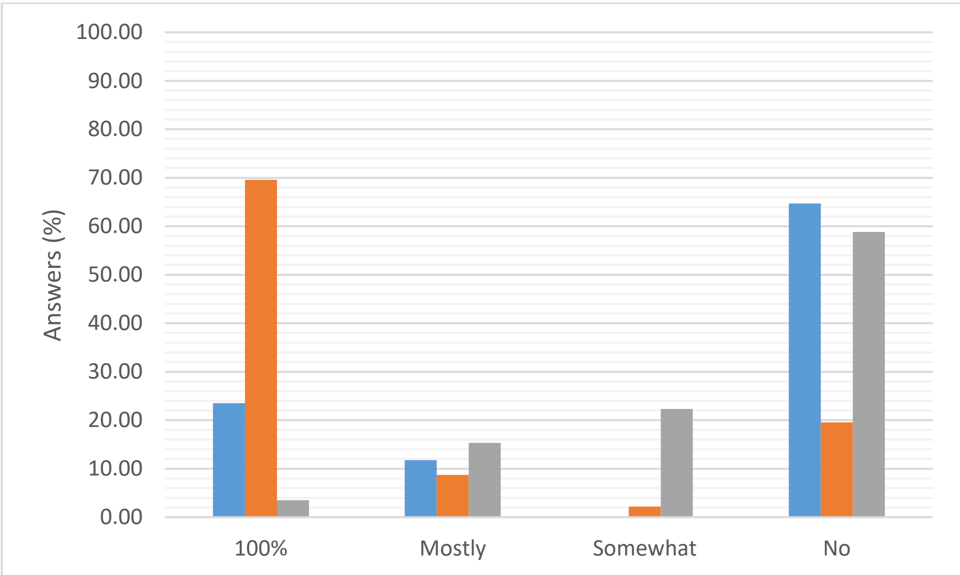


*Figure 34.* Percentage of answers to Question 26) Is decision-making by the authorities open (transparent)? That is, do you understand why decisions are made they are? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

In NAFO area and Castelló all fishermen and their families have access to Primary Health Care (PHC). This situation is different in the Aegean Sea. Most fishermen have access to PHC but there are some who do not have access or partial access (Fig. 35).

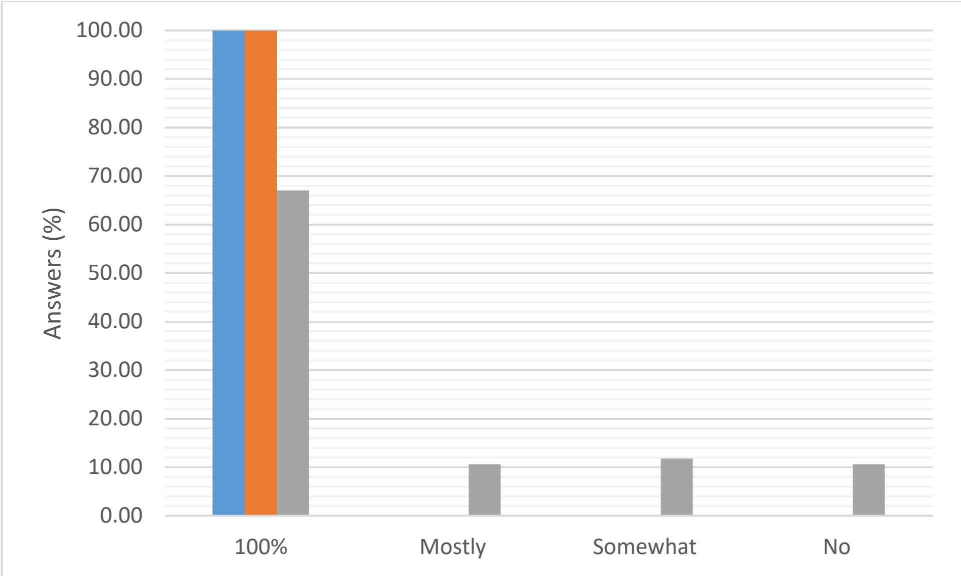


*Figure 35.* Percentage of answers to Question 27) Do you and your family have access to primary health care? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

With regard to insurance for families in case sailors suffer any damage during their fishing activity, there are great differences between the three regions sampled. On the one hand, in the case of Castelló, the majority of fishermen have 100 % insurance to their families. On the other hand, Spanish fishermen that work in NAFO have only some help. Finally, most fishermen from Aegean Sea do not have insurance. For those who do have it, it is a private insurance (Fig. 36).

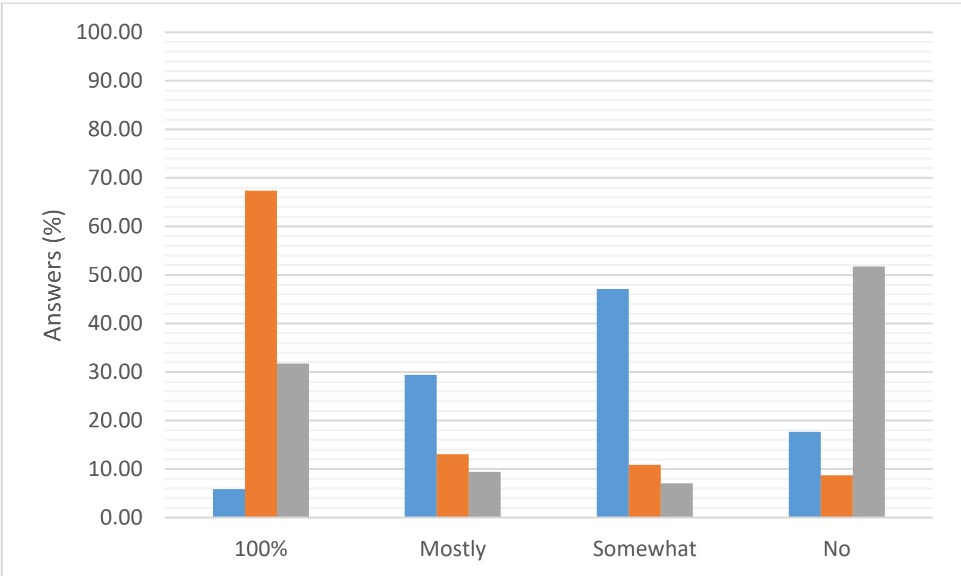


*Figure 36.* Percentage of answers to Question 28) Will your family be taken care of if you are injured fishing? (by the government or with insurance? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

Both Castelló and Aegean Sea fishing fleets are aged. The vast majority of fishermen have been working in the sector for more than twenty years. And many others around fifteen years. Few fishermen have little practice in the profession. In the case of the industrial fleet of NAFO area the age of the fishermen is younger. Most of them have been working for five to twenty years (Fig. 37).

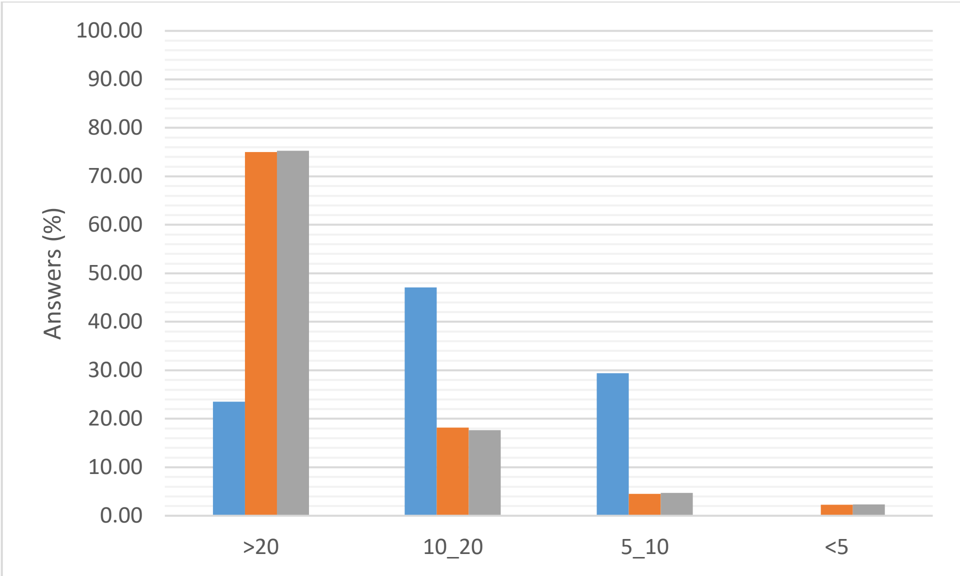


*Figure 37.* Percentage of answers to Question 29) How many years have you been engaging in fishing? **Blue**: NAFO, **Orange**: Castelló and **Grey**: Aegean.

In all regions sampled, biological factor was the one with the most variability in terms of the responses provided by fishermen. With regard to economic and social factors, the responses were more unanimous. Both globally and in the particular cases of the fleets in each region.

## 3.2 Vulnerability Assessment

The VA score for individual respondents was calculated using the survey results. The results show an even distribution of respondents under the various levels of VA in the three different regions (Fig. 38). While 34 % of the respondents scored a low Vulnerability level in NAFO and Aegean regions, the same percentage 34 % but in very high Vulnerability answers was the result in Castelló. The majority of the respondents scored a 22 % from the other levels.

The VA score for all regions was close 2.78 (Table 11) indicating medium level of Vulnerability. The highest Vulnerability score appears in Aegean region. In contrast, the lowest Vulnerability score is from Castelló.

The score for all groups was different for each indicator (Table 12) indicating Exposure, Sensitivity and Adaptive Capacity levels. The average of these indicators was employed to calculate the vulnerability level on different areas studied.

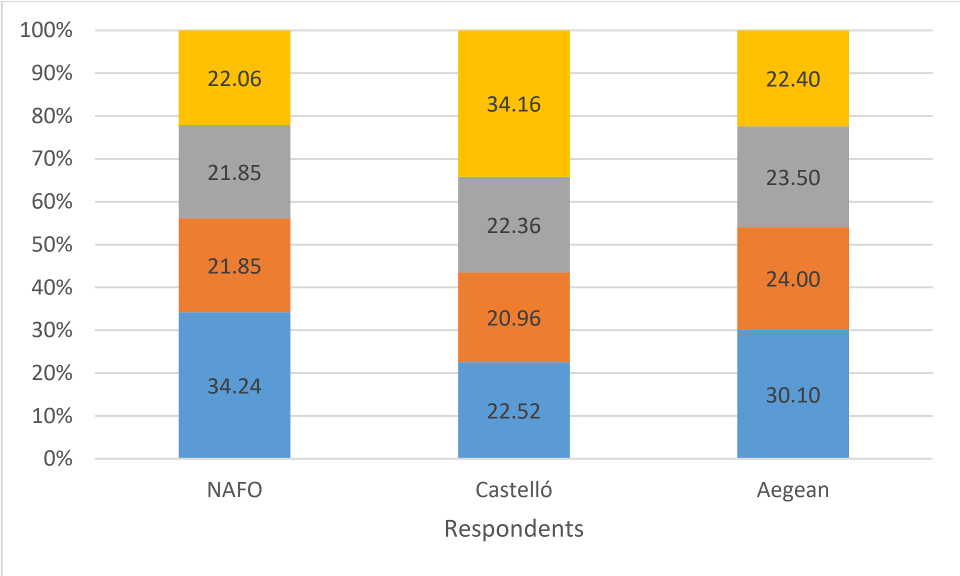


*Figure 38.* Distribution of respondents by Vulnerability levels: Very High (VH), High (H), Moderate (M), Low (L).

*Table 11.* Vulnerability of 3 fishing areas: NAFO, Castelló and Aegean. Scores for each dimension of Exposure, Sensitivity, Adaptive Capacity and a Cumulative Vulnerability score, calculated as equation 5.

| **Area** | ***Exposure*** | ***Sensitivity*** | ***Adaptive Capacity*** | ***Cumulative Vulnerability*** |
|---|---|---|---|---|
| **NAFO** | 2.71 | 2.24 | 2.19 | 2.76 |
| **Castelló** | 2.50 | 2.96 | 2.60 | 2.86 |
| **Aegean** | 2.43 | 2.56 | 2.27 | 2.72 |

Table 12. *Aggregate VA Scores of all Respondents, NAFO, Castelló and Aegean Respondents.*

| | NAFO | Castelló | Aegean |
|---|---|---|---|
| **Number of respondents** | **17** | **46** | **85** |
| **Climate factors** | 1,59 | 1,54 | 1,92 |
| **Fishing revenues** | 3,76 | 3,96 | 2,67 |
| **Other revenues** | 3,76 | 4,00 | 3,36 |
| **Catch consumption** | 1,00 | 3,98 | 3,31 |
| **Fishing modalities** | 2,88 | 2,74 | 2,32 |
| **Change modality** | 2,88 | 2,00 | 2,78 |
| **Change species** | 1,12 | 2,74 | 2,36 |
| **Catch composition** | 3,00 | 2,96 | 2,82 |
| **Catch size** | 3,76 | 2,52 | 2,44 |
| **Fish size** | 2,82 | 2,76 | 2,60 |
| **Labour opportunities** | 2,06 | 3,59 | 2,93 |
| **Economic helps** | 3,12 | 2,00 | 2,04 |
| **Governmental helps** | 2,12 | 1,30 | 1,07 |
| **Administrative requirements** | 1,00 | 2,61 | 2,16 |
| **Family size** | 2,18 | 2,83 | 2,64 |
| **Professional education** | 2,65 | 3,07 | 2,14 |
| **Available education** | 2,24 | 1,35 | 1,62 |
| **Formal education** | 1,76 | 1,87 | 2,03 |
| **Share information** | 1,53 | 2,91 | 3,00 |
| **Good laws** | 1,82 | 2,22 | 2,04 |
| **Law enforcement** | 1,88 | 2,07 | 1,87 |
| **Governmental interest** | 2,59 | 1,57 | 1,98 |
| **Law application** | 1,35 | 1,78 | 1,82 |
| **Change laws quickly** | 2,00 | 1,59 | 1,87 |
| **Transparency** | 1,76 | 3,76 | 1,64 |
| **Primary attention** | 1,94 | 4,00 | 3,34 |
| **Insurance** | 4,00 | 3,72 | 2,28 |
| **Age** | 2,24 | 3,67 | 3,66 |

*Exposure, Sensitivity and Adapt Capacity.

### 3.3 Proposals for Adaptive Capacity measures

Previously, the threats to which fishing is exposed have been determined, as well as their Sensitivity and the capacity to adapt to them. In this section, local action plans are proposed and the time for their implementation is determined (Table 13). Adaptive Capacity measures are designed to mitigate Exposure, reduce Sensitivity and improve the Adaptive Capacity of the fishing regions analysed.

*Table 13*. Adaptive Capacity measures to reduce Vulnerability. Short term: less than 1 year. Short-Medium term: 1 – 2 year. Medium term: 3 year. Medium-Long term: 3 – 5 year. Long term: more than 5 year.

| Indicators | Adaptive Capacity measures | Application time |
|---|---|---|
| **Climate factors** | CC mitigation, incorporating CC into natural resource planning sectors.<br>Reduction greenhouse emissions.<br>Improve information about weather.<br>Investment in alternative energy.<br>Carbon trading policies. | Medium-Long term |
| **Fishing revenues** | To guarantee a remunerated and continuous work for the Fishermen within the own sector.<br>Effective arrangements for stakeholder's engagement.<br>Diversification of markets and fish products, access to high value markets, support to diversification of citizens' demands and preferences.<br>Provide incentives for fish product value addition and market development. | Medium term |
| **Catch consumption** | Educate fishermen to appreciate all the species as the same environmental value. | Short-Medium term |

| Indicators | Adaptive Capacity measures | Application time |
|---|---|---|
| **Fishing modalities** | Diversify the fishery to new gear and target species may help to reduce Sensitivity to the impacts of CC.<br>Gear replacement schemes.<br>Social protection and safety nets. | Medium-Long term |
| **Species**<br>**Change species**<br>**Catch composition**<br>**Catch size**<br>**Fish size** | Such fisheries may thus be more sensitive to shifts and would need to respond much more proactively to disruptive changes resulting from CC.<br>Moving to other fishing grounds and by shifting gear.<br>Enhancing natural barriers, protecting fish habitats through adaptive spatial management.<br>Temporal and spatial planning to permit stock recovery during periods when climate is favourable.<br>Management measures to make marine ecosystems more resilient.<br>Regional conservation plan.<br>Increase the number of MPAs.<br>Switching target species or gear type or moving to marginally productive areas.<br>Information based tools such as early warning systems can reduce lost or unproductive fishing days.<br>Adaptation plans. | Medium term |
| **Labour opportunities** | Supplemental livelihood activities could reduce Sensitivity by starting to link fishing households with new occupational sectors.<br>Supporting the development of alternative or diversified livelihoods.<br>Exit strategies for fishers to leave fishing. | Long term |

| Indicators | Adaptive Capacity measures | Application time |
|---|---|---|
| **Governmental helps** | Facilitate government aid processes.<br>Remove harmful incentives.<br>To carry out the projects that are developed from the EU and the different NGOs that work in the correct development of the fishing sector. | Medium-Long term |
| **Family size** | Ensure better work-life balance. | Medium term |
| **Professional education** | Environmental education and participation in research activities.<br>Training and public awareness initiatives. | Short-medium term |
| **Available education** | Inform fishermen from the available courses to improve their skills. | Short term |
| **Formal education** | Increase school enrolment ratios (secondary education). | Long term |
| **Share information** | Financial planning and management, knowledge and information sharing. | Medium term |
| **Good laws** | Legal support to CC issues at national and international levels.<br>Incorporating uncertainty into decision-making and management process.<br>Awareness raising and capacity building to integrate CC into research, management, policy and rules.<br>Incorporation of traditional knowledge in management planning and advice for decision-making. | Medium term |
| **Law application** | Eradicate corruption. | Short-Medium term |

| Indicators | Adaptive Capacity measures | Application time |
|---|---|---|
| **Government interest** | Livelihood diversification.<br>Encompassing legislation.<br>CC adaptation policies and plans address fisheries.<br>Plans and programmes elaboration. Participation in national and international committees.<br>Research and monitoring. | Long-term |
| **Change laws quickly** | Support for community initiatives.<br>Strengthening community groups responsible for managing coastal resources.<br>Enable co-management and governance among stakeholders.<br>Adaptive legal rules. | Short term |
| **Transparency** | Addressing issues such as corruption, transparency, and stability of national governments will be key to building effective social organization and AC at all scales. | Long term |
| **Primary attention** | Investment public primary attention. | Long term |
| **Insurance** | Investment health insurances. | Medium-Long term |
| **Fishermen aged** | Elaboration of an aid plan for fishing maritime training schools and creation of new ones.<br>Facilitating access for future young fishers.<br>Training them to carry out a sustainable fishing activity that respects the marine ecosystem and the environment. | Medium-Long term |

# 4 DISCUSSION

## 4.1 Methodology

One of the problems added to this work is the difference between data size. For this reason, one must be cautious when interpreting the results. Another problem has been the language. It is true that, in Turkey, interviews have been conducted with interpreters who have facilitated the translation of the surveys. Nevertheless, a great deal of qualitative information has been lost. Because interviewers often did not write down everything the fishermen told them because a) they did not consider it relevant, or b) just completed the survey.

Surveys were used to obtain information on biological, social and economic characteristics of SSF in Castelló and Turkish Aegean Sea and one case of industrial fishery in NAFO area. In addition, to show fishermen perception from different fishing modalities that are working in Castelló. Also, to compare between three fishing areas located in the Aegean Turkish Sea. The loadings obtained in each variable as a result from PCA identified the degree of perception from fishermen to CC. Other authors use this methodology to create an Index to measure the Adaptive Capacity to CC (Thathsarania and Gunaratneb, 2018). The second analysis developed was VA.

VA methodologies have also traditionally been categorized as top-down and bottom-up (FAO, 2015). This study focuses on bottom-up approach, surveying various fishers who operate fisheries for their livelihood.

## 4.2 Vulnerability Assessment

Interpretation of vulnerability from the risk/hazard, political, economy or ecology, and resilience schools of thought. These are three dominant disciplinary traditions that have a strong influence on how research on V is carried out (Adger, 2006). This study has shown how applying IPCC VA methodology, to assess the Vulnerability of three different fishing regions, has enabled quantification of the areas at risk from effects of CC and other threats. Therefore the main data presented in this study were collected by direct and personal interviews with fishers.

Exposure, Sensitivity, and Adaptive Capacity influence the Vulnerability of fishery-based livelihoods in varied ways. Those who are most exposed are not necessarily the most sensitive or least able to adapt (IPCC_A, 2014). NAFO area, Castelló (Spain) and Aegean Sea (Turkey) regions show a moderate level of Vulnerability in this study. These levels are similar to those identified at the relative vulnerabilities of economies to the impacts of CC on their fisheries sectors. Canada and Spain have a low Vulnerability level in contrast with Turkey which has a moderate Vulnerability level (FAO, 2015) and high Exposure level (Allison *et al*, 2009).

The VA can be applied to assess the perception from fishermen of how climate change affects their daily fishing activities. For example, if the objective of VA is to increase the knowledge level of fishermen about understanding effects of climate change, maybe workshops could be incorporated and hence, a new VA score can be obtained. Then the new VA could be contrasted with baseline VA to assess the intervention's effect on fishermen vulnerability. However, this study assess VA from fishing activity, and from a bottom-up approach instead top-down approach (Allison *et al*., 2009).

Direct interviews with fishermen were employed for measuring index-scores of chosen indicators. Hence, this approach was free from limitations. In addition, survey method for VA was least affected by measurement-source error and self-reported data error. Furthermore, we were able to conform reliable fishermen survey data collection to the few missing response frequencies. This is how the approach could be useful to address the missing data problem (Ahsan and Warner, 2014).

The contextual nature of vulnerability, the difficulties of validating indicators, and considerations of timescale, provide challenges to the development of robust indicators (Adger and Vincent, 2005). Indicators were selected to enhance our understanding about the changes taking place in the sea and how these might affect fishermen and their fishing activities, also their adaptive capacity and strategies. This project want to know how vulnerable is fishing activity and fishermen livelihood are, also their ability and capacity to adapt to climate changes which may take place in studied fishing areas.

The VA essentially comprises predictive indicators of vulnerability based on existing insights, but as shown above a number of subjective decisions and assumptions are embodied in the methodology. One of the main reasons for this uncertainty is not being able to validate the effectiveness of the indicators in representing determinants of vulnerability, as indeed the whole objective of indicators is to capture intangible processes (Adger and Vincent, 2005).

### 4.2.1 Exposure:

In this project, Exposure is represented by six variables within biological factor. These variables try to determine the degree to which fishermen perceive the effects of CC on their daily fishing activities.

Marine temperature level is increasing (IPCC_A, 2014). Simultaneously, fishermen reflect that this climatic factor is one of the most influential to their fishing activity. The other climatic factor is storm. The frequency of storminess is expected to increase and sea level rise is expected to continue, which would negatively impact fishing activities (Peck and Pinnegar, 2018). CC effects may also increase the intensity and size of weather events (Hidalgo *et al.*, 2018). The consequences would include a disruption of climate patterns and increased storminess and frequency of heat waves (Shelton, 2014; Bahri *et al.*, 2018).

Due to these changes in climatic factors induced by CC, species are changing. In the Mediterranean Sea this is the so-called merialization phenomenon, applying it to designate the presence of species typical of southern and warm latitudes that colonise latitudes located to the north of their place of origin (Lloris, 2015). This has a substantial impact on the habitats of important fish species in the fisheries sector (Ünal *et al*., 2019). In Mediterranean eastern region, in Aegean Sea *Lagocephalus sceleratus* was first mentioned in the Mediterranean Sea by Mouneimne (1977). And *L. sceleratus* was reported for the first time in the Mediterranean Sea in 2003 off Akayka, Gökova Bay in Turkey (Akyol *et al*. 2005). In recent years the invasive marine fish *L. sceleratus* (Silver-cheeked toadfish) had the biggest impact on both local species and the socio-economic well-being of fishers (Ünal *et al.*, 2015; Ünal and Göncüoğlu, 2017; Ünal *et al.*, 2019). The presence of these new species, overfishing and CC are changing catch composition of fishing areas. Luckily most of the immigrant fish species are marketable (Peck and Pinnegar, 2018). For example, other species like *Saurida undosquamis* are also invading the Mediterranean. But to fight this situation Akyaka fishing cooperative (Gökova bay) started selling Brushtooth lizard fish to control its population and obtain economic retribution from this resource. The problem is that local people do not know about the fish and they are not feeling comfortable buying it.

Whereas the majority of fishermen respond that catch decreased in the last decades. Some fishermen responded to a short-term increase in catch that lasted 4 months after a previously closed area was open to fishing (Cinner *et al*., 2009). Some fishermen from Castelló trawling fleet are of the same opinion and answered the same. In addition due to the local action measures of the trawl fleet being adopted by the "Cofradía de Pescadors de Sant Pere del Grao de Castelló" fish catch grew in last three years. Also this growth coincides with the rest of the national trend (Fig. 39a). In the Aegean region, to SSF, catch levels are generally low (Ünal and Franquesa, 2010). In the last decade, the country's catches have only decreased (Fig. 39b). Excluding southern region where there are differences between other parts of Turkey. It is about community based marine ranger system in practice at the south and NGOs such as

Mediterranean Conservation Society is very active in the Gökova Bay where three southern cooperatives are located. And eventually, species richness and fisheries catch potential are projected to increase, on average, at mid and high latitudes and decrease at tropical latitudes (IPCC_A, 2014).

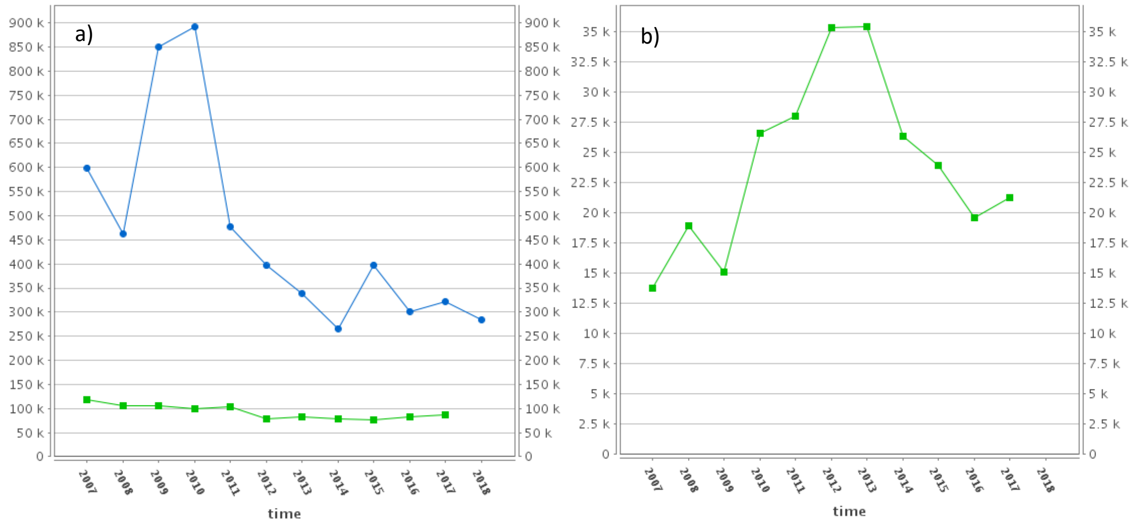


*Figure 39.* a) Catches in the Mediterranean and b) Catches in NAFO area (Tonnes live weight). Spain and Turkey. (Source: Eurostat and FishstatJ).

Finally, in response to CC and intensive fishing, widespread reductions in fish body size and in the mean size of zooplankton have been observed over time and these trends further affect the sustainability of fisheries (IPPC_B, 2014). In this study, the majority of fishermen responded with the same argument.

### 4.2.2 Sensitivity:

In this study, Sensitivity is represented by seven variables within economic factor. These variables try to determine how fishermen face the new situations generated by the threat of CC.

NAFO and Castelló fishermen generate their income directly from fishing unlike the fishermen of the Aegean Sea. In this region, the majority of SSF activities have a negative or insufficient economic performance (Tzanatosa *et al.*, 2006; Ünal and Franquesa, 2010). Only a few fishermen receive all their income from fishing. The majority of fishermen on the Aegean Sea complements their incomes with other jobs. The practice of an additional professional activity by fishermen is frequent. Few studies exist on the dependence of professional fishermen on fishing activity as a source of income. Some elements concerning the dependence of coastal fishermen in Finland (Salmi, 2005) showed that two thirds of fishermen get less than 30% of their income from fisheries contrarily to the present study where more than half of the fishermen earn almost all their income from fisheries (Tzanatosa *et al.*, 2006).

Moreover, fishermen of the Aegean region are the ones who consume the most fish from their catches like Galician fishermen who work at NAFO area. In contrast with Castelló fleets that give less than 5 % of their catch to family. In general fishermen from Galicia receive part of their salary keeping a portion of the catch as payment (Vázquez, 2016). This practice is known as "Quiñón".

In all regions, the majority of fishermen have continued to fish with the same gear that they have always used to carry out their daily fishing activity. The majority of fishermen in Castelló employ gillnets and bottom longlines. Like in the Aegean central region where fishermen combine both fishing modalities. Trawlers and Purse-seiners are more or less similar in number of vessels in Castelló. In the particular case of NAFO, the fishing modality is bottom trawling, it is a case of industrial fishing.

Fishermen who decide to change their gear in recent years, they did it for a variety of reasons. Although most began to use different arts by changes in law or regulations, change in conditions at sea, change in target species (more, fewer, different), practical reasons (maintenance problems, worn out old could not replace, hard to use…), financial reasons (old gear too expensive, new gear more profitable), labour reasons (new gear needs less labour) and safety.

Other reasons why fishermen decided to change their fishing gear is the advancement of technology. During the last century, the improvement in fisheries technologies (more efficient vessel design, more powerful engines, mechanization of fishing operations, vessel positioning systems, echo-sounders and radar, among others) has increased the fishing capacity of fleets (Pauly *et al.*, 2002). Above all, those who have experienced the most drastic changes are the artisanal fleets. Because they have gone from fishing with wooden boats to larger and safer fiberglass vessels.

On the one hand, if fishermen cannot go fishing anymore or decide to stop their fishing activity their options are limited. Maybe they could start on agriculture or move to another region to find a new job. Also, 25 % of Aegean fishermen expressed their desire to leave the profession. However, they remain in business as it provides self-employment, and fishermen continue fishing due to lack of alternative opportunities (Ünal and Franquesa, 2010). On the other hand, in many Mediterranean countries a person wishing to be a professional fisherman has to have the necessary skills (Tzanatosa *et al.*, 2006). In Spain, a fisherman must show that he has the necessary skills, proven by a navigation/fishing certificate. In Italy, pass a training course. In Algeria, prove that he has spent at least 12 months at sea (Cacaud, 2005).

Lastly, only a few fishermen indicated that they received some kind of help from the government. Excluding Turkey, countries members in EU should receive an economic help. Since European Maritime and Fisheries Fund (EMFF) within European Commission grants funds to all countries to cover the six “Union Priorities” defined in the EMFF, namely: 1. Promoting environmentally sustainable, resource-efficient, innovative, competitive and knowledge-based fisheries and aquaculture; 2. Implementation the Common Fisheries Policy (CFP); 3. Increasing employment and territorial cohesion; 4. Fostering marketing and processing; 5. Implementation of the Integrated Maritime Policy (IMP). However, fishermen refused to receive financial assistance of any source.

### 4.2.3 Adaptive Capacity:

In this work Adaptive Capacity is represented by sixteen variables within social factor. These variables try to assess how effective are the measures and policies currently being employed in the three sampled regions to address CC.

The capacity to adapt in Europe is high compared to other world regions, but there are important differences in impacts and in the capacity to respond between and within the European sub-regions. In Europe, adaptation policy has been developed at international (European Union), national, and local government levels, including the prioritization of adaptation options. There is limited systematic information on current implementation or effectiveness of adaptation measures or policies. Some adaptation planning has been integrated into coastal and water management, as well as disaster risk management (IPPC_B, 2014). Similarly, social Adaptive Capacity and Sensitivity are also amenable to policy actions. In simple terms, local-level actions can help to reduce the V of coastal communities to the impacts of CC.

In the present study, one of the social variables analysed was the one that obtained the best consensus on the part of the fishermen. When answering the question 15. “Have you experienced changes in fishing as an activity? (as a daily routine, what you are or are not allowed to do, heavier/lighter reporting requirements, more or less dangerous)? How have you dealt with it?” All fishermen, regardless of their response, agreed on one thing: Bureaucratic procedures have increased dramatically since they started fishing with their parents and grandparents.

Fishermen's families are usually large families, with four or five members. Although, it is not uncommon to find sailors who are single and have no family charge. However, regardless of the number of members that make up the family there is one thing for sure and that is that most fishermen have learned the trade by themselves or by family tradition and their formal education is very limited. Majorly of fishermen had at best finished preliminary school, while few fishermen had attained education past high school. So they only know the trade of fishermen. Therefore, if for some reason they ceased their activity it would be difficult for them to find another job outside the maritime sector. It is possible to have access to vocational training to learn a new trade. However the fishermen are not aware of these aids and do not ask for them.

Access to information and communications infrastructure is arguably important in influencing vulnerability (Thathsarania and Gunaratneb, 2018). For these reason, communication has to improve between stakeholders. Unfortunately, many fishermen today do not trust fishing authorities and do not share their knowledge with them. Luckily, the entry of some environmental NGOs as new stakeholders is causing fishermen to share their information with them and with scientists. This echo will facilitate the development of management plans based on the EAF, management measures and laws that can cope with new climatic situations.

Implementation of new regulations is urgently needed to preserve the livelihood of professional fishermen (with a well-defined professional identity) whose livelihoods depend entirely on fishing (Ünal and Franquesa, 2010). The policy implications of vulnerability and resilience are profound and contested. Policies and strategies, which reduce vulnerability and promote resilience change the status quo for many agencies and institutions and are frequently resisted (Adger, 2006). At present, the policies and measures in place do not take into account ecosystem approaches or tools for mitigating CC.

In order to build mutual trust and confidence and to promote effective implementation, an enhanced transparency framework (Kalikoski *et al*., 2018) law must be transparent. On three different regions sampled there are no problem with that. Because in all cases the law is public and transparent. Free access for all users who want to access it. In addition, for the results of assessments to be used effectively and appropriately in adaptation decision planning, it is important to be transparent about the underlying assumptions and caveats of the assessment process and its results (FAO, 2015).

Primary Health Care (PHC) is an approach to health beyond the traditional health care system that focuses on health equity-producing social policy (Starfield, 2011). PHC includes all areas that play a role in health, such as access to health services, environment and lifestyle (Marcos, 2004). Thus, primary healthcare and public health measures, taken together, may be considered as the cornerstones of universal health systems (White, 2015). In Spain, everybody have access to PHC. The healthcare system in Turkey has a highly complex structure. The Ministry of Health

(MOH), universities and the private sector are the health service providers in the Turkish health system. For instance; Emergency care is free for Turkish citizens including those without state health insurance. Emergency departments are open non-stop all year and can be reached by dialling 112. By 2008 all ambulances, which are used in 112 Emergency Health Services, were accredited to the European standards (Akdag, 2008).

In addition, fishermen also need life insurance to protect them. Since fishing is considered a risky profession. In all regions, fishermen stated that they were in possession of these insurances and that they were also private. Because the government does not take charge if fishermen are injured at sea during their fishing activity.

In this study, in addition to assessing vulnerability to the threat of CC, other factors were also assessed. Due to the evaluation of the social factor it has been possible to ascertain that fishermen population are aged in all regions. In Greek Aegean Sea, the mean fisherman age was 49 (Tzanatosa *et al.*, 2006). In this way a threat was found that was not contemplated. Today there is no generational relay that can continue the work in the fishing sector. For this reason, this is possibly the threat that makes fishing more vulnerable in the short and medium term. Notwithstanding, there are a few young fishermen who continue to do the work of their parents and grandparents. But this is something unusual. This trend also brings with it a decline of artisanal fisheries in many coastal zones and this situation is leading to a loss of traditional ecological knowledge of fishers (Lloret *et al.*, 2018).

And eventually, in last years the Ideology of CC denial appears. Denialism is an essentially irrational action that withholds the validation of a historical experience or event, when a person refuses to accept an empirically verifiable reality (O'Shea, 2008). Frighteningly, this idea has a large number of followers, including political leaders from countries with highly developed industries. These politicians are detrimental to environment. Because denying the evidence of CC entails denying the need for a plan to mitigate its action. Therefore, there would be no policies or financial support for CC assessments, no strategies and no management based on ecosystem approaches. So all the work done so far to combat CC would be lost.

# 5 CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Conclusions

- The main climatic stressors of the three sampled areas are the increase in temperatures and the increased presence of storm events. Especially for smaller gear fleets, such as Castelló and the Aegean Sea, as they have smaller boats. And they are therefore more vulnerable to these more abrupt climatic events.
- Fishermen are not aware of the aid offered to them, both economically and in terms of training.
- Adaptive Capacity is the tool that stakeholders have to mitigate the effects of CC on the fishing sector.
- Bureaucratic procedures have increased heavily in last twenty years.
- Apart from CC, another two clear threats are affecting fisheries in the three studied areas. First, fishing is a sector with an aging professional population and unfortunately there is no generational relay. Secondly, invasive species are changing catch composition. Above all in the Aegean Sea, which is seriously affected by the presence of lessepsian species.
- Vulnerability level of the sampled areas (NAFO, Castello and Aegean) is moderate. In more detail, studied areas have similar levels in term of Exposure, Sensitivity and Adaptive Capacity.
- VA helps to structure our thinking about the ways in which CC is affecting fishermen. The framework also helps to identify and organize the opportunities and challenges in dealing with these problems. But this study is the beginning; adaptation to CC and other global environmental change is an iterative process that requires both top-down and bottom-up processes.

## 5.2 Recommendations

- Finalise the VA by bringing stakeholders together. Evaluate the adaptation measures proposed in this study and analyse their possible causes and effects. And finally, implement them and evaluate the results.
- Carry out a VA taking into account the different types of fleets operating in the maritime waters of the Valencian Community.
- Develop a standard VA model so that each Autonomous Community can develop its own VA and be able to share it at national level.
- Develop a standard VA model so that each Mediterranean countries can develop its own VA and be able to share it at international level.
- Assess the effects on fisheries of CC, overexploitation of fisheries and pollution as a whole.

# 6 REFERENCES


- Adger, W.N. (2000). Social and ecological resilience: are they related? *Progress in Human Geography* 24, pp. 347–364.
- Adger, W.N. and Vincent, K. (2005). Uncertainty in adaptive capacity. *Comptes Rendus Geoscience* 337, pp. 399–410.
- Adger, W.N., Hughes, T.P., Folke, C., Carpenter, S.R. and Rockstrom, J. (2005). Social-ecological resilience to coastal disasters. *Science* 309, pp. 1036–1039.
- Adger, W.N., (2006). Vulnerability. *Global Environmental Change* 16 (3), pp. 268–281.
- Ahsan, N. and Warner, J. (2014). The socioeconomic vulnerability index: A pragmatic approach for assessing climate change led risks–A case study in the south-western coastal Bangladesh. *International Journal of Disaster Risk Reduction* 8, pp. 32–49.
- Akyol, O., Ünal, V., Ceyhan, T. and Bilecenoglu, M. (2005). First confirmed record of *Lagocephalus sceleratus* (Gmelin, 1789) in the Mediterranean Sea. *Journal of Fish Biology* 66, pp. 1183–1186.
- Akdag, R. (2008). Saglikta Donüsüm Programi. *Saglik Bakanligi Yayin* (749), 140 pp.
- Allison, E.H., Perry, A.L., Badjeck, M.C., Adger, W.N., Brown, K., Conway, D., Halls, A.S., Pilling, G.M., Reynolds, J.D., Andrew, N.L., Dulvy, N.K. (2009). Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and Fisheries* 10, pp. 173–196.
- Bahri, T., Barange, M. and Moustahfid, H. (2018). Chapter 1: Climate change and aquatic systems; in *Impacts of climate change on fisheries and aquaculture. Synthesis of current knowledge, adaptation and mitigation options.* FAO FISHERIES AND AQUACULTURE TECHNICAL PAPER 627. pp 1–17.
- Cacaud, P. (2005). Fisheries laws and regulations in the Mediterranean: a comparative study. *General Fisheries Commision for the Mediterranean, Studies and Reviews* No. 75, Rome. 58 pp.
- Cheung, W.W.L., Watson, R. and Pauly, D. (2013). Signature of ocean warming in global fisheries catch. *Nature* 497, pp. 365–368.
- Cinner, J.E., Daw, T. and McClanahan, T.R. (2009). Socioeconomic Factors that Affect Artisanal Fishers' Readiness to Exit a Declining Fishery. *Conservation Biology* 23(1), pp. 124–130.

- Cinner, J.E., Mc Clanahan, T.R., Graham, N.A.J., Dawc, T.M., Maina, J., Stead, S.M, Wamukota, A., Brown, K. and Bodin, O. (2012). Vulnerability of coastal communities to key impacts of climate change on coral reef fisheries. *Global Environmental Change* 22, pp. 12-20.
- Cinner, J.E., Huchery, C., Darling, E.S., Humphries, A.T., Graham, N.A.J., Hicks, C.C., Marshal, N. and McClanahan, T.R. (2013). Evaluating Social and Ecological Vulnerability of Coral Reef Fisheries to Climate Change. *PLoS ONE* 8(9): e74321.
- Cochrane, K.L., Rakotondrazafy, H., Aswani, S., Chaigneau, T., Downey-Breedt, N., Lemahieu, A., Paytan, A., Pecl, G., Plagányi, E., Popova, E., van Putten, E.I., Sauer, W.H.H., Byfield, V., Gasalla, M.A., van Gennip, S.J., Malherbe, W., Rabary, A., Rabearisoa, A., Ramaroson, N., Randrianarimanana, V., Scott, L. and Tsimanaoraty, P.M. (2019). Tools to Enrich Vulnerability Assessment and Adaptation Planning for Coastal Communities in Data-Poor Regions: Application to a Case Study in Madagascar. *Front. Mar. Sci.* 5:505.
- Dyck, A. J. and Sumaila, U. R. (2010). Economic impact of ocean fish populations in the global fishery. *Journal Bioeconomics* 12, pp. 227–243.
- Ekstrom, J.A., Suatoni, L., Cooley, S.R., Pendleton, L.H., Waldbusser, G.G., Cinner, J.E., Ritter, J., Langdon, C., Hooidonk, R., Gledhill, D., Wellman, K., Beck, M.W., Brander, L.M., Rittschof, D., Doherty, C., Edwards, P.E.T. and Portela, R. (2015). Vulnerability and adaptation of US shellfisheries to ocean acidification. *Nature Climate Change* 5(3), pp. 201-214.
- España. Decreto 48/2018, de 20 de abril, del Consell, por el que se modifica el Decreto 59/2017, de ordenación de la pesca artesanal del pulpo. [2018/4075] Diari Oficial de la Generalitat Valenciana, 25 de abril de 2018, núm. 8281, pp. 16045-16047.
- España. Orden AAA/399/2016, de 18 de marzo, por la que se reconocen, a efectos de ayudas, paradas voluntarias realizadas en la pesca de la modalidad de cerco en determinadas zonas del litoral de la Comunitat Valenciana. Boletín Oficial del Estado, 29 de marzo de 2016, núm. 76, pp. 22808-22809.
- España. Orden APA//254/2008, de 31 de enero, por la que se establece un Plan integral de gestión para la conservación de los recursos pesqueros en el Mediterráneo. Boletín Oficial del Estado, 7 de febrero de 2008, núm. 33, pp. 6877-6879.
- España. Resolución de 5 de julio de 2017, del director general de Agricultura Ganadería y Pesca, por la que se establecen las épocas de veda para la pesca artesanal del pulpo (Octopus vulgaris). [2017/6782] Diari Oficial de la Generalitat Valenciana, 24 de julio de 2017, núm. 8090, pp. 26117.

- FAO. (2008). Climate change and food security: A framework document. Interdepartmental Working Group on Climate Change. 107 pp.
- FAO. (2012). Training guide - gender and climate change research in agriculture and food security for rural development, CCAFS & FAO. 136 pp.
- FAO. (2015). Assessing climate change vulnerability in fisheries and aquaculture: Available methodologies and their relevance for the sector, by Cecile Brugère and Cassandra De Young. FAO Fisheries and Aquaculture Technical Paper No. 597. Rome, Italy.
- FAO. (2018). The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals. Rome. Licence: CC BY-NC-SA 3.0 IGO.
- Gregg, R.M., Score, A., Pietri, D. and Hansen, L. (2016). The state of climate adaptation in US marine fisheries management. Bainbridge Island, WA, USA, EcoAdapt. 110 pp.
- Hansen, J., Ruedy, R., Sato, M. and Lo, K. (2010). Global surface temperature change. Reviews of *Geophysics*, 48(4): RG4004.
- Hidalgo, M., Mihneva, V., Vasconcellos, M. and Bernal, M. (2018). Chapter 7: Climate change impacts, vulnerabilities and adaptations: Mediterranean Sea and the Black Sea marine fisheries; in *Impacts of climate change on fisheries and aquaculture. Synthesis of current knowledge, adaptation and mitigation options*. FAO FISHERIES AND AQUACULTURE TECHNICAL PAPER 627. pp. 139 - 158.
- Holling, C.S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics* 4, pp. 1–23.
- IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1132.
- IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)].

Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 688.

- Kalikoski, D.C., Jentoft, S., Charles, A., Herrera, D.S., Cook, K., Béné, C. and Allison, E.H. (2018). Chapter 2: Understanding the impacts of climate change for fisheries and aquaculture: applying a poverty lens; in *Impacts of climate change on fisheries and aquaculture. Synthesis of current knowledge, adaptation and mitigation options*. FAO FISHERIES AND AQUACULTURE TECHNICAL PAPER 627. pp. 19-40.
- Kersting, D.K. (2016). Cambio climático en el medio marino español: impactos, vulnerabilidad y adaptación. Oficina Española de Cambio Climático, Ministerio de Agricultura, Alimentación y Medio Ambiente. Madrid, 166 pp.
- Kiessling, T., Salas, S., Mutafoglu, K. and Thiel, M. (2017). Who cares about dirty beaches? Evaluating environmental awareness and action on coastal litter in Chile. *Ocean and Coastal Mgmt* 137, pp. 82–95.
- Koen-Alonso, M., Pepina, P., Fogartyb, M.J., Kennyc, A. and Kenchingtond, E. (2018). The Northwest Atlantic Fisheries Organization Roadmap for the development and implementation of an Ecosystem Approach to Fisheries: structure, state of development, and challenges. *Marine Policy* 100, pp. 342-352.
- Le Quéré, C., Andrew, R.M., Friedlingstein, P., Sitch, S., Pongratz, J., Manning, A.C. and Korsbakken, J.I. (2018). *Global carbon budget* 2017. Earth System Science Data, 10(1), pp. 405–448.
- Link, J. S., Kohler, B., Griffis, R., (Peg) Brady, M. M., Ito, S.-I., Garc¸on, V., Hollowed, A., Barange, M., Brown, R., and Wawrzynski, W. (2018). A graphic novel from the 4th International Symposium on the Effects of Climate Change on the World's Oceans. – ICES *Journal of Marine Science*.
- Lloret, J., Cowx, I.G., Cabral, H., Castro, M., Font, T., Gonçalves, J.M.S., Gordoa, A., Hoefnagel, E., Matić-Skokog, S., Mikkelsen, E., Morales-Nin, B., Moutopoulos, D.K., Muñoz, M., Neves dos Santos, M., Pintassilgo, P., Pita, C., Stergiou, K.I., Ünal, V., Veiga, P. and Erzini, K. (2018). Small-scale coastal fisheries in European Seas are not what they were: Ecological, social and economic changes. *Marine Policy* 98, pp. 176-186.
- Lloris, D. (2015). *Ictiofauna Marina. Manual de identificación de los peces marinos de la peninsula ibérica y Baleares*. Ediciones Omega, S.A. 674 pp.
- Marcos, C. (2004). The ORIGINS of Primary Health Care and SELECTIVE Primary Health Care. *Public Health* 22(94), pp. 1864–1874.

- Marshall, N.A. and Marshall, P.A., (2007). Conceptualizing and operationalizing social resilience within commercial fisheries in northern Australia. *Ecology and Society* 12, 1.
- McDermott, G., Meng, K., McDonald, G. and Costello, C. (2019). The blue paradox: Preemptive overfishing in marine reserves. *Proc Natl Acad Sci USA* 116(12), pp. 5319-5325.
- Morrison, W.E., Nelson, M.W., Howard, J.F., Teeters, E.J., Hare, J.A., Griffis, R.B., Scott, J.D. and Alexander, M.A. (2015). Methodology for Assessing the Vulnerability of Marine Fish and Shellfish Species to a Changing Climate. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OSF-3, 48 pp.
- Mouneimne, N. (1977). Liste des poissons de la côte du Liban. *Cybium* 1, pp. 37–66.
- NAFO. (2018). *Conservation and Enforcement Measures*. Serial No. N6767. NAFO/COM Doc. 18-01. 190 pp.
- O'Shea, P. (2008). *A Cross Too Heavy: Eugenio Pacelli, Politics and the Jews of Europe 1917-1943.* Ed. Rosenberg Publishing. 392 pp.
- Pauly, D., Christensen, V., Guénette, S., Pitcher, T.J., Sumaila, U.R., Walters, C.J., Watson, R. and Zeller, D. (2002). Towards sustainability in world fisheries. *Nature* 418, pp. 689–695.
- Peck, M. and Pinnegar, J.K. (2018). Chapter 5: Climate change impacts, vulnerabilities and adaptations: North Atlantic and Atlantic Arctic marine fisheries; in *Impacts of climate change on fisheries and aquaculture. Synthesis of current knowledge, adaptation and mitigation options*. FAO FISHERIES AND AQUACULTURE TECHNICAL PAPER 627. pp. 87-111.
- Poulain, F., Himes-Cornell, Amber and Shelton, C. (2018). Chapter 25: Methods and tools for climate change adaptation in fisheries and aquaculture; in *Impacts of climate change on fisheries and aquaculture. Synthesis of current knowledge, adaptation and mitigation options*. FAO FISHERIES AND AQUACULTURE TECHNICAL PAPER 627. pp. 535 – 566.
- Rilov, G., Peleg, O., Yeruham, E., Garval, T., Vichik, A. and Raveh, O. (2017). Alien turf: Overfishing, overgrazing and invader domination in south-eastern Levant reef ecosystems. *Aquatic Conserv: Mar Freshw Ecosyst*. pp. 1–19.
- Roessig, J.M., Woodley, C.M., Cech, J.J. and Hansen, L. (2004). Effects of global climate change on marine and estuarine fishes and fisheries. *Fish Biology and Fisheries* 14, pp. 251-257.
- Salmi, P. (2005). Rural pluriactivity as a coping strategy in small-scale fisheries. *Sociologia Ruralis* 45(1/2), pp. 22–36.

- Shelton, C. (2014). Climate change adaptation in fisheries and aquaculture – compilation of initial examples. FAO Fisheries and Aquaculture Circular No. 1088. Rome, FAO. 34 pp.
- Snoussi, M., Ouchani, T. and Niazi, S. (2008). Vulnerability assessment of the impact of sea-level rise and flooding on the Moroccan coast: The case of the Mediterranean eastern zone. *Estuarine, Coastal and Shelf Science* 77, pp. 206-213.
- Solomon, O., Ahmed, O. and Eyiwunmi, A. (2018). Mitigation measures to avert the impacts of plastics and microplastics in the marine environment (a review). *Environmental Science and Pollution Research* 25(10), pp. 9293-9310.
- Starfield, B. (2011). Politics, primary healthcare and health. Epidemiol Community Health 65, pp. 653–655.
- Sumaila, U.R., Cheung, W.W.L., Lam, V.W.Y., Pauly, D. and Herrick, S. (2011). Climate change impacts on the biophysics and economics of world fisheries. *Nature Climate Change* 1, pp. 449-456.
- Thathsarania, U.S. and Gunaratneb L.H.P. (2018). Constructing and Index to Measure the Adaptive Capacity to Climate Change in Sri Lanka. *Procedia Engineering* 212, pp. 278–285.
- Tilley, A., Herrón, P., Espinosa, S., Angarita, J.L. and Box, S. (2018). Predicting vulnerability to management changes in data-limited, small-scale fisheries. *Marine Policy* 94, pp. 39-45.
- Tzanatosa, E., Dimitriou, E., Papaharisisc, L., Roussid, A., Somarakisa, S. and Koutsikopoulosa, C. (2006). Principal socio-economic characteristics of the Greek small-scale coastal fishermen. *Ocean & Coastal Management* 49, pp. 511–527.
- Ulman, A., Bekişoğlu Ş., Zengin, M., Knudsen, S., Ünal, V., Mathews, C., Harper, S., Zeller, D. and Pauly, D. (2013). From bonito to anchovy: a reconstruction of Turkey's marine fisheries catches (1950-2010). Mediterranean marine science 14(2), 34 pp.
- Ünal, V. and Franquesa, R. (2010). Technical note: A comparative study on socio-economic indicators and viability in small-scale fisheries of six districts along the Turkish coast. *Applied Ichthyology* 26, pp. 26.34.
- Ünal, V., Göncüoğlu H., Durgun D., Tosunoğlu Z., Deval M.C., Turan C. (2015). Silver-cheeked toadfish, *Lagocephalus sceleratus* (Actinopterygii: Tetraodontiformes: Tetraodontidae), causes a substantial economic losses in the Turkish Mediterranean coast: A call for decision makers. *Acta Ichthyol. Piscat* 45(3), pp. 231-237.
- Ünal, V., Göncüoğlu H. and Miran, B. (2016). Analyzing Fishery Cooperatives for Developing Specific Policy Recommendation in Turkey. Paper presented in Economic

Advice in Fisheries Management (4-5 February 2016): a Trilogue between Science, Administration and Stakeholders, St Julians, Malta.

- Ünal, V. and Göncüoğlu H. (2017). The socio-economic impacts of the silver-cheeked toadfish on small-scale fishers: A comparative study from the Turkish coast. *Ege Journal of Fisheries and Aquatic Sciences* 34(2), pp. 119-127.
- Ünal, V., Derya Yıldırım, Z. and Mümtaz Tıraşın, E. (2019). Implementation of the ecosystem approach to fisheries for the small-scale fisheries in Gökova Bay, Turkey: baseline report. FAO Fisheries and Aquaculture Technical Paper No. 646, 68 pp.
- UNEP-MAP RAC/SPA. (2009). Sub-regional report on vulnerability and impacts of climate change on marine and coastal biological diversity in the North Mediterranean non-Adriatic countries and Israel. By Charton-Garcia, J., Cebrian, D., Limam, A., Zenetos, A., Galil, B., Badalamenti, F., Ozturk, B., Marba Bordalba, N., Rizzo, M., Borg, D., Saliba, S. and Hajichristoforou, M. Ed. RAC/SPA, Tunis; 44 pp.
- UNFCCC. (2011). Fact Sheet: Climate Change Science—The Status of Climate Change Science Today. United Nations Framework Convention on Climate Change, New York.
- Vázquez, J.M. (2016). Quiñones y jornales pesqueros en galicia: la singular empresa de porto do Son, 1788-1789. *Drassana* 24, pp. 48-65.
- White, F. (2015). Primary health care and public health: foundations of universal health systems. *Med Princ Pract* 24, pp. 103-116.

## 6.1 Web Sites

Ayuntamiento de Castelló. “Presentació de la Ciutat”. (Jan. 3, 2019; http://www.castello.es/web30/pages/generico_web10.php?cod1=26&cod2=157) (Consulted Jan. 3, 2019).

Eurostat. “Your key to European statistics”. (Set. 29, 2019; https://ec.europa.eu/eurostat/web/fisheries/data/main-tables) (Consulted Set. 29, 2019).

Generalitat Valenciana. “Conselleria de Agricultura, Medio ambiente, Cambio Climático y Desarrollo Rural”. (Jan. 8, 2019; http://www.agroambient.gva.es/es/web/cidam/pesca-75909;) (Consulted Jan. 8, 2019).

Instituto Nacional de Estadística (INE) España (ed.). “Revisión del Padrón municipal 2018. Datos por municipios. Castellón”. (Jan. 3, 2019; http://www.ine.es/jaxiT3/Datos.htm?t=2865) (Consulted Jan. 3, 2019).

## 6.2 Figures


Figure 1. Roessig, J.M., Woodley, C.M., Cech, J.J. and Hansen, L. (2004). Effects of global climate change on marine and estuarine fishes and fisheries. *Fish Biology and Fisheries* 14, pp. 251-257.

Figure 2. Sumaila, U.R., Cheung, W.W.L., Lam, V.W.Y., Pauly, D. and Herrick, S. (2011). Climate change impacts on the biophysics and economics of world fisheries. Nature Climate Change 1, pp. 449-456.

Figure 3. FAO. (2015). Assessing climate change vulnerability in fisheries and aquaculture: Available methodologies and their relevance for the sector, by Cecile Brugère and Cassandra De Young. FAO Fisheries and Aquaculture Technical Paper No. 597. Rome, Italy.

Figure 4. Fisheries and Oceans Canada. Government of Canada. (Apr. 26, 2016; http://www.dfo-mpo.gc.ca/international/media/bk_nafo-opano-eng.htm) (Consulted Mar. 14, 2019).

Figure 5. Miguellín. Mapa de localización de la provincia de Castelló. BY-SA 3.0 (Nov. 17, 2010; https://es.wikipedia.org/wiki/Castell%C3%B3n_de_la_Plana#/media/File:Castell%C3%B3n-loc.svg (Consulted Feb. 25, 2019).

Figure 6. Minimalaegean. Póster "Mapa del Mar Egeo póster mínimo". (May. 22, 2018; https://www.redbubble.com/es/people/minimalaegean/works/30795315-mapa-del-mar-egeo-m-nimo?p=poster (Consulted Abr. 16, 2019).

Figure 10c. Dammous, S. *Siganus rivulatus; picture (Siriv_u4.jpg)*. (May. 11, 2000; https://www.fishbase.se/photos/PicturesSummary.php?StartRow=2&ID=4545&what=species&TotRec=7 (Consulted May. 28, 2019).

Figure 38. Poulain, F., Himes-Cornell, Amber and Shelton, C. (2018). Chapter 25: Methods and tools for climate change adaptation in fisheries and aquaculture; in *Impacts of climate change on fisheries and aquaculture. Synthesis of current knowledge, adaptation and mitigation options*. FAO FISHERIES AND AQUACULTURE TECHNICAL PAPER 627. pp. 535 – 566.

# 7 APPENDIXES

## 7.1 APPENDIX A

### 7.1.1 Survey questionnaire with indicators scoring criterion:

**Introduction**

Climate change is happening no matter if we can observe or experience it or not. It may have affected your fishing activity and your livelihood either in a gradual path or in a dramatic way. In this survey, we aim to enhance our understanding about the changes taking place in the sea and how these might affect you and your fishing activities, also your adaptive capacity and strategies. The survey we will conduct with you is the part of the project, we want to know how vulnerable your fishing activity and your livelihood are, also your ability and capacity to adapt to climate changes which may take place in your fishing areas. The results can be used for decision makers both in the fishing sector and authority levels in making appropriate investment and management decisions in light of climate change and its associate (potential) effects. Thus, your participation and honest answers are important for us to deliver the right results and immediate needs required by you.

1. Which climate stressor will affect fish and your fishing the most?
   A. Temperature [1]
   B. Storm [2]
   C. Acidification [3]
   D. Sea rise [4]

2. How much of your income (percent) comes from fishing? Chose the best answer:
   A. 100% [4]
   B. 75% [3]
   C. 50% [2]
   D. Less than 25% [1]

3. How much income do you receive from other activities than fishing? Chose the answer that is best:
   A. Less than 25% [4]
   B. 50% [3]
   C. 75% [2]
   D. 100% [1]

4. How much of your catch do you, your family(ies) and friends consume? (percent) Chose the best answer.
   A. Less than 5% [4]
   B. 10% [3]
   C. 15% [2]
   D. More than 20% [1]

5. What top five fish species do you harvest?
   - Specify:

6. Have you changed your fishing gear in the past 5 – 10 years?
   A. Yes, from past ______________________________________________________

      to current ______________________________________________________ [1]

   B. No, have not changed [3]

7. If you have changed your fishing gear in the last decade, why did you do that?
   A. Changes in law/regulation [3]
   B. Change in conditions at sea [3]
   C. Change in target species (more, fewer, different) [4]
   D. Practical reasons (maintenance problems, worn out old could not replace…) [4]
   E. Financial reasons (old gear too expensive, new gear more profitable) [2]
   F. Labor reasons (new gear needs less labor) [2]
   G. Safety [1]
   H. Others, specify________________________________________________ [1]

8. Have the species you harvest changed in the last 10 years? If so, from what to what?
   A. Yes, from (past species)__________________________________________________
      to (current species)___________________________________________________ [1]
   B. No, have not changed [3]

9. Has your catch composition changed in the last (two) decade?
   A. Yes – one species no longer dominates catch. (Explain which species used to dominate:
   ____________________________________________________________________
   ____________________________________________________________ [1]
   B. Yes – a different species now dominates the catch (the species that used to dominate: ______________________________________________________; the species that dominates now: ________________________________________________ [3]
   C. Yes – the mix of species has changed:
   More of____________________________________________________________
   less of _______________________________________________________ [2]
   D. No, has not changed [4]

10. Has your total catch increased, been stable or decreased in the last (last two) decade(s)?
   A. Increased [4]
   B. Stable (no change) [3]
   C. Decreased [2]
   D. NK / NA [1]

11. Has the size of the fish that you harvest changed in the last decade or two?
   A. Yes, have changed from smaller fish to bigger fish [4]
   B. Yes, have changed from bigger fish to smaller fish [2]
   C. No change [3]
   D. NK / NA [1]

12. What choices do you have if you cannot (or are not allowed to) go fishing anymore?
   A. Fish farming (e.g., farm sea bass/sea bream, mussels, etc.) [1]
   B. Move to other region or town to find other jobs [2]
   C. Agriculture [3]
   D. Others, specify ___________________________________ [4]

13. Do you get financial help from private sources such as your family, friends or communities?
   A. Yes, from my family or my friends [4]
   B. Yes, from the community [3]
   C. No, [2]
   D. Others, specify _____________ [1]

14.Do you get compensation from the government if your income from fishing is reduced?

A. Yes, it covers all the losses [4]

B. Yes, it covers a big part of the losses (more than 50%) [3]

C. Yes, it covers a small part of losses (less than 30%) [2]

D. No, none [1]

15.Have you experienced changes in fishing as an activity? (as a daily routine, what you are or are not allowed to do, heavier/lighter reporting requirements, more or less dangerous)? How have you dealt with it?

A. Yes,

expain______________________________________________________________________

_______________________________________________________________________________[3]

B. No, explain

_______________________________________________________________________________

_______________________________________________________________________________ [1]

16.What is your family size (including yourself, wife or husband, your children)?

A. 3 [2]

B. 4 [3]

C. 5 [4]

D. Others, specify______ [1]

17.Have you received formal or informal training in your profession?

A. Yes, some kind of schooling from__________________________________________ [4]

B. Yes, my family taught me(_______________________________________________) [3]

C. Yes, my friends taught me (explain_________________________________________) [2]

D. No. I learned on my own. [1]

18.Is training available if you want to change professions?

A. Yes, with full or partial government support [4]

B. Yes, though a labor union or worker's association (explain____________________) [3]

C. Yes, but I have to pay all the costs myself [2]

D. No, there is none available [1]

19. What is your highest formal education?

A. College [4]
B. High school [3]
C. Secondary school [2]
D. No formal schooling [1]

20. Do you feel you can share information with fishing authorities?

A. Yes, usually [4]
B. Sometimes [3]
C. No, never [2]
D. NK /NA [1]

21. Do you feel authorities have the capacity to determine good rules for fishing?

A. Yes, they are generally very competent and can make decisions [4]
B. Yes, they are good at some things but not others [3]
C. No, they are competent but unable to make decisions [2]
D. No, they are generally incompetent and can never make a decision [1]

22. Is there adequate enforcement of the rules/laws/regulations?

A. Rules and regulations are always enforced [4]
B. Rules and regulations are usually enforced [3]
C. Rules and regulations are only sometimes enforced [2]
D. There is no enforcement at all [1]

23. Do (fisheries authorities) listen to you when you report on fish or fishing? (for example, when you feel catches are lower or higher than expected, or the rules are not working as expected, etc)

A. Always [4]
B. Mostly [3]
C. Sometimes [2]
D. Never [1]

24.Do fishing authorities apply the rules fairly?

A. Yes, they are 100% fair [4]

B. Yes, they are mostly fair [3]

C. Yes, they are sometimes fair [2]

D. No, they are not fair at all [1]

25.Can authorities change rules quickly to respond to new situations?

A. Yes with 100% response [4]

B. Yes most responses [3]

C. Yes some responses [2]

D. No responses [1]

26.Is decision-making by the authorities open (transparent)? That is, do you understand why decisions are made they are?

A. Yes they are 100% open [4]

B. They are mostly open [3]

C. They are somewhat open [2]

D. Not open at all [1]

27.Do you and your family have access to primary health care?

A. Yes. 100% access [4]

B. Yes, most of the time [3]

C. I have some access [2]

D. I have no access [1]

28.Will your family be taken care of if you are injured fishing? (by the government or with insurance?)

A. Yes, 100% [4]

B. Yes mostly [3]

C. Some help, but not so much [2]

D. Not at all [1]

29. How many years have you been engaging in fishing?

A. More than 20 years [4]

B. Between 10 – 20 years [3]

C. Between 5 – 10 years, [2]

D. New (around one year) [1]

## 7.2 APPENDIX B

### 7.2.1 Name of the species that appears in these study:

*Table 14.* Fish species.

| FAO CODE | SCIENTIFIC NAME | SPANISH | CATALAN | TURKISH | ENGLISH |
|---|---|---|---|---|---|
| AMB | *Seriola dumerili* | Seriola | Letxa | Sarikuyruk | Amberjack |
| ANE | *Engraulis encrasicolus* | Boquerón | Aladroc | Hamsi | Anchovy |
| ANN | *Diplodus annularis* | Raspallón | Raspall | Isparoz | Annular Seabream |
| BBS | *Scorpaena porcus* | Cabracho | Escórpora | Adabeyi | Black scorpionfish |
| BFT | *Thunnus thynnus* | Atún rojo | Tonyina | Orkinos | Bluefin tuna |
| BLI | *Molva dypterygia* | Maruca azul | Escolà | | Blue ling |
| BLU | *Pomatomus saltatrix* | Anchova | Tallahams | Lüfer | Bluefish |
| BOG | *Boops boops* | Boga | Boga | Lopa balığı | Bogue |
| BON | *Sarda sarda* | Bonito | Bonito | Palamut | Bonito |
| BSS | *Dicentrarchus labrax* | Lubina | Llobarro | Levrek | Sea bass |
| COD | *Gadus morhua* | Bacalao | Abaejo | | Atlantic cod |
| CTB | *Diplodus vulgaris* | Sargo | Vidriada | Karagöz | Two-banded seabream |
| DEC | *Dentex dentex* | Dentón | Déntol | Sinağrit | Dentex |
| DOL | *Coryphaena hippurus* | Lampuga | Llampuga | Lambuga | Mahi-mahi |
| ELE | *Anguilla anguilla* | Anguila | Anguila | Avrupa Yilan balığı | European eel |
| GAR | *Belone belone* | Aguja | Agulla | Zargana | Garfish |
| GDG | *Gadiculus argenteus* | Marujito | Ulls | Pamukcuk balığı | Silver pout |

| | | | | | |
|---|---|---|---|---|---|
| GHL | *Reinhardtius hippoglossoides* | Fletán negro | | | Greenland halibut |
| GPD | *Epinephelus marginatus* | Mero | Mero | Orfoz | Dusky grouper |
| GPW | *Epinephelus aeneus* | Cherna | | Lagos | White grouper |
| HAL | *Hippoglossus hippoglossus* | Fletán blanco | | | Atlantic halibut |
| HKE | *Merluccius merluccius* | Merluza | Lluç | Bakalyaro | European hake |
| HKN | *Merluccius australis* | Rosada | | | Southern hake |
| HOM | *Trachurus trachurus* | Jurel | Sorell | Istavrit | Horse mackerel |
| HSU | *Sargocentron rubrum* | Candil rubio | | Hindistan balığı | Redcoat |
| IGU | *Siganus spp* | Pez conejo | | Sokar | Rabbit fishes |
| LEE | *Lichia amia* | Palometón | Palomida | Akya | Leerfish |
| LFZ | *Lagocephalus sceleratus* | | | Balon balığı | Silver-cheeked toadfish |
| LIB | *Saurida undosquamis* | Lagarto | | Lokum balığı | Brushtooth lizardfish |
| LTA | *Euthynnus alletteratus* | Bacoreta | Bacoreta | Yazili Orkinos | Little tunny |
| LZZ | *Liza spp.* | Lisa | Llissa | Kefal | Mullet |
| MAC | *Scomber scombrus* | Caballa | Verat | Uskumru | Atlantic mackerel |
| MAS | *Scomber japonicus* | Estornino | Verat d'ull grós | Kolyoz | Chub mackerel |
| MEG | *Lepidorhombus whiffiagonis* | Gallo | Bruixa | Pisi balığı | Megrim |
| MON | *Lophius piscatorius* | Rape | Rap | Fener balığı | Monkey fish |
| MUR | *Mullus surmuletus* | Salmonete de roca | Moll | Tekir | Striped red mullet |
| MUT | *Mullus barbatus* | Salmonete de fango | Moll | Barbun | Red mullet |
| NNJ | *Nemipterus randalli* | | | Kilkuyruk mercan | Japan threadfin bream |
| PAC | *Pagellus erythrinus* | Pagel | Pagell | Kirma Mercan | Pandora |

| | | | | | |
|---|---|---|---|---|---|
| PIL | *Sardina pilchardus* | Sardina | Sardina | Sardalya | Sardine |
| RED | *Sebastes spp* | Gallineta | | Kirmizi balığı | Redfish |
| RJR | *Amblyraja radiata* | Raya | Rajada | | Starry ray |
| RPG | *Pagrus pagrus* | Pargo | Pagre | Mercan | Red porgy |
| SAA | *Sardinella aurita* | Alacha | Alatxa | Yuvarlak sardalya | Round sardinella |
| SBA | *Pagellus acarne* | Aligote | Besuc | Yubani Mercan | Axillary seabream |
| SBG | *Sparus aurata* | Dorada | Orada | Çipura | Gilt-head sea bream |
| SBZ | *Diplodus cervinus* | Sargo real | Sarg | Çizgili isparoz | Zebra seabream |
| SBS | *Oblada melanura* | Oblada | Oblada | | Saddled seabream |
| SOL | *Solea solea* | Lenguado | Llenguado | Dil balığı | Common sole |
| SSB | *Lithognathus mormyrus* | Herrera | Mabre | Mirmir | Sand Steenbras |
| SWA | *Diplodus sargus* | Sargo | Sarg | Sargos | White seabream |
| SWO | *Xiphias gladius* | Pez espada | Peix espasa | Kiliç balığı | Swordfish |
| WHB | *Micromesistius poutassou* | Bacaladilla | Mòllera | Mezgit | Blue whiting |

*Table 15.* Non-Fish species.

| FAO CODE | SCIENTIFIC NAME | SPANISH | CATALAN | TURKISH | ENGLISH |
|---|---|---|---|---|---|
| ARA | *Aristeus antennatus* | Gamba roja | Gamba | Kirmizi Karidesi | Blue shrimp |
| CTC | *Sepia officinalis* | Sepia | Sépia | Sübye | Cuttlefish |
| DPS | *Parapenaeus longirostris* | Gamba blanca | Gamba blanca | Karides | Deep-water rose shrimp |
| KUP | *Penaeus japonicus* | Langostino | Llagostí | Kuruma Karidesi | Kuruma prawn |
| MTS | *Squilla mantis* | Galera | Galera | Mantis karidesi | Mantis shrimp |
| OCC | *Octopus vulgaris* | Pulpo | Polp | Ahtapot | Octopus |
| SLO | *Palinurus elephas* | Langosta | Llagosta | Böcek | Lobster |
| SQI | *Illex illecebrosus* | Pota | Pota | Akdeniz kalamari | Northern shortfin squid |
| QQR | *Loligo vulgaris* | Calamar | Calamar | Kalamar | European squid |

## 7.3 APPENDIX C

### 7.3.1 R-project script employed to run PCA:

```
install.packages(psych)

mydata<-read.csv(file.choose(),header=TRUE)

head(mydata)

cor(mydata)

### PCA and FA ###

# Principal Components

fit<-princomp(mydata, cor=TRUE)

summary(fit) # print variance accounted for

loadings(fit) # pc loadings

plot(fit,type="lines") # scree plot

fit$scores # the principal components

biplot(fit)

# Varimax Rotated Principal Components: orthogonal rotation of the factorial axes. The objective is to get the correlation of each of the variables as close to 1 with only one of the factors and close to zero with all the others.

library(psych)

fit<-principal(mydata, nfactors=1, rotate="varimax")

fit # print results
```

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El Máster Internacional en GESTIÓN PESQUERA SOSTENIBLE está organizado conjuntamente por la Universidad de Alicante (UA), el Centro Internacional de Altos Estudios Agronómicos Mediterráneos (CIHEAM) a través del Instituto Agronómico Mediterráneo de Zaragoza (IAMZ), el Ministerio de Agricultura, Pesca y Alimentación (MAPA) a través de la Secretaría General de Pesca (SGP).

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*The International Master in SUSTAINABLE FISHERIES MANAGEMENT is jointly organized by the University of Alicante (UA), the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM) through the Mediterranean Agronomic Institute of Zaragoza (IAMZ), and by the Spanish Ministry of Agriculture, Fisheries and Food (MAPA) through the General Secretariat of Fisheries (SGP).*

*The Master is developed over two academic years. Upon completion of the first year (a programme based on lectures, practicals, supervised work, seminars and technical visits), during the second part the participants devote a period of 10 months to initiation to research or to professional activities conducting an original research work through the elaboration of the Master Thesis. The present manuscript is the result of one of these works and has been defended before an examination board.*